ELECTRON

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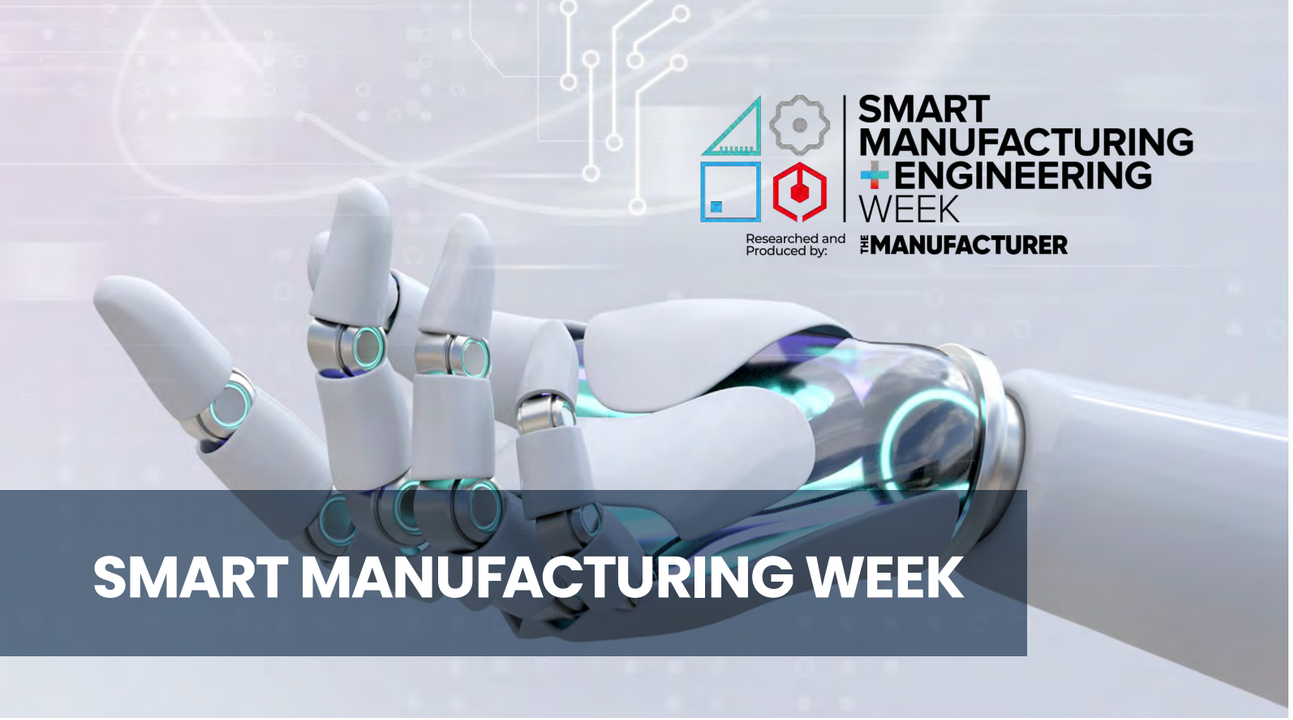


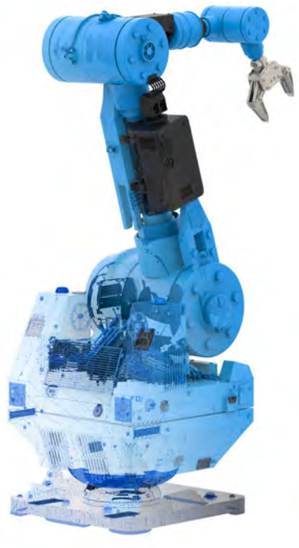
SMART MANUFACTURING WEEK

One of the UK's largest engineering exhibitions, Smart Manufacturing Week, now in its fourth year, returned to the National Exhibition Centre in Birmingham on 4th. and 5th. June. Around 450 exhibitors were supported by around 140 presentations covering Automation and Robotics, Design and Innovation, Digital Transformation, IOOT and Connectivity, Industrial Data and AI, Institute for Manufacturing Masterclass, Leadership and Strategy, and a Technology Showcase Arena.

The exhibition itself was sub-divided into Smart Factory Expo, Design Engineering Expo, Drives and Controls, Maintec, Air-Tec and Fluid Power and Systems. The majority of the exhibitors (220) were located in the Smart Factory Expo and Design Engineering Expo areas. Key features included the STEM Showcase, now extended to include school year students as well as those in further education, affording the opportunity to interact directly with industry experts, and a new 'Smart Tank' allowing entrepreneurs to pitch business ideas and product concepts to a panel of industry experts, based on a well-known TV format and forming part of the 'Innovation Alley', which featured emerging manufacturing technologies grouped under 'People', 'Product', 'Process' and 'Planet'.

New for 2025 was the Technology Showcase Theatre which afforded visitors an opportunity to view future developments and prototypes in fields such as advanced robotics and wearable technologies, whilst the Manufacturing Digitalisation Summit returned providing a two-day conference specifically for industry leaders and incorporated The Manufacturer Top 100 Awards.

Other new features for 2025 included the VIP demo experience from Fracture Reality and the 'Accubots' from accu.co.uk. JoinXR by Fracture Reality allowed attendees to discover how extended reality is revolutionising engineering workflows by accelerating design processes and decision-making, aligning cross-functional teams with greater clarity, scaling technical training and onboarding, and reducing costly misunderstandings in complex builds. Meanwhile the 'Accubots' (miniature 150g fighting robots) represented a scaled down version of the larger Accubots competition.



The Five Pillars of Smart Manufacturing Week

Smart Manufacturing Week 2025 identified, through research conducted by Hennik Research, five themes that are considered to be key to the manufacturing sector.

The partnership aims to support up to 47,000 young people to enjoy their own Big Bang at School day with special science and engineering activities, workshops and projects designed to arouse passion and curiosity for all things related to STEM. The objective is to bring tyhe same fun, excitement and interactive learning experiences that are provided by the Big Bang fair to the classroom to benefit 11 to 14-year-olds.

1. **Sustainability and Circular Economy:**
   Sustainability and the challenge of achieving Net Zero are seen as both a regulatory necessity and a catalyst for innovation and efficiency. As such the exhibition aimed to provide a platform for visitors to explore solutions that minimised environmental impact, and a Sustainability Stream in the event's educational agenda.

2. **Digital Transformation:**
   The integration of digital technologies is transforming manufacturing and so the show sought to highlight the tools needed to enhance operations. This was reflected in the seven Solutions Theatre presentations incorporated into the educational agenda, and in the Manufacturing Digitalisation Summit where the importance of the application of digital technologies to enhance processes, efficiencies and outcomes for manufacturing formed part of the programme.

3. **Workforce Development and Upskilling:**
   This pillar was a response to the fact that over the past year 97 per cent of manufacturers reported the hiring and retention of skilled workers to be a major challenge. Manufacturers are notably increasingly requiring expertise in areas such as automation, AI and data analysis, and with 80 per cent stating that they are struggling to find workers with the necessary digital skills, workforce development has been recognised as a growing concern. In response the show sought to establish partnerships with Women into Science and Engineering, the Women's Engineering Society, Innovate UK and Cambridge University's Institute for Manufacturing, and set up a dedicated Manufacturers and Engineers of the Future Programme. Sessions were purposefully organised to address upskilling and provide opportunities for both employers and potential employees to connect.

4. **Innovation and Smart Technologies:**
   This pillar recognised that innovation has to be at the heart of modern manufacturing and so the Innovation Alley was introduced to draw attention to breakthrough innovation, in particular from start-ups and university spinouts. The 'Smart Tank' and Technology Showcase Arena were also introduced under this pillar.

5. **Supply Chain Resilience:**
   This pillar highlighted the importance of maintaining a resilient supply chain and was enhanced by promoting innovative strategies and new technologies that aim to overcome disruption and create agile systems. An example was Epicor with its kinetic cloud-based ERP solution.

Supporting Exhibitions

Alongside Smart Manufacturing Week were the already established TCT3Sixty, dedicated specifically to additive manufacturing (3D-printing), Med Tech, Subcon and Automechanika.

This year TCT3Sixty featured around 150 exhibitors and ten speakers presenting on an Insights stage and an Innovation stage, with topics including 'Optimising Additive Manufacturing with AI and Digital Twin' (Javaid Butt, Professor of Manufacturing and Product Design, Birmingham City University), 'Enabling faster Development of Space Propulsion Technologies by Additive Manufacturing of VDM780' (Juri Munk, Researcher, DLR), 'Realising an Order-of-Magnitude Growth in the UK Aerospace Additive Manufacturing Sector' (Matthew Bailey, Lead Technologist, Aerospace Technology Institute), 'Boosting Productivity with Beam-Shaping: Insights from using AMCM M290-2FLX' (Ruaridh Mitchinson, AM Technology Manager, The Manufacturing Technology University of Bristol), and 'Can you dig it? 3D Technology for Museum Research, Conservation and Exhibition' (Tom Ranson, 3D Visualisation Specialist, Natural History Museum).

Javaid Butt most notably said:

> *"I believe that innovation in AM is no longer primarily about machines and materials, but is increasingly becoming more about data intelligence. Digital twins and AI together redefine that intelligence is offering a pathway to smarter, sustainable and more adaptable manufacturing"*

Other highlights of this exhibition included Project TAMPA, an ongoing project established in 2021 to accelerate the use of AM in the UK defence industry, the TCT Awards, and Print City MMU's live design competition in which Manchester Metropolitan University's MSc students were challenged to optimise part designs to exhibit strength and high performance in a repeatable manner.

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Med-Tech Innovation Expo

The Med-Tech Innovation Expo provided a hub for showcasing state-of-the-art medical technologies and groundbreaking solutions.

This exhibition featured around 200 exhibitors and, as with TCT3Sixty, it had an Insights stage and an Innovation stage. There were 22 speakers , the majority of which were on the Innovation stage. Topics included 'How we built the UK's First AI Physiotherapist' (Ric da Silva, Co-Founder and Chief Technical Officer, Flok Health), 'Growing Adoption of Minimally Invasive Devices in Cardiovascular Space: Addressing the Challenges' (Natalya Vanyagina, Head of EMEA Marketing, Elixir Medical), 'Biomarkers are the Future for improving Patient Outcomes' (Les Lindsey, President, Kiffik Biomedical), 'The Future of Data-driven Healthcare Transformation: How harnessing Data from the OR can drive Medtech Innovation and Accessibility' (Richard Carter, Chief Technical Officer, Proximie), 'Synthetic Soft Tissues for Surgical Training', (Richard Arm, Senior Research Fellow, Nottingham Trent University), 'AI in Medical Device Quality Assurance', (David Shute, Zeiss), 'Connected Healthcare: Understanding the Testing and Compliance Requirements for Wireless Medical Devices' (Alex Toohie, Element Material Technology), and 'The Critical Role of SBOM and Firmware Security in Medical Device Cybersecurity Compliance' (Julian Sarrade, Keysight).

Exhibitors included notably Dexter Magnetic Technologies, whose technologies are enabling miniaturisation, biocompatibility, high precision and performance optimisation to solve challenges which traditional MEMS and piezoelectric devices cannot achieve. Also of interest was the Ultrasonic Surgical System, or Ultrasonic Scalpel, from Innolcon Medical Technology Company Limited, which is a groundbreaking piece of clinical surgical equipment that uses ultrasonic energy to promote hemostatic cutting and coagulation of soft tissues, and to cut and seal vessels up to 7mm in diameter.

Subcon

This exhibition, now in its 51st. year, featured around 170 exhibitors and 50 CPD accredited workshops and session is a show that aimed 'to redefine the supply chain with cutting edge innovations'.

Key features this year included a 10 per cent increase in floor area compared with 2024, a motorsport-grade simulator experience with professional race driver Michael O'Brien with the best contestant winning a track-day experience at Bedford Aerodrome, the Manufacturing Solutions Show Awards, and a dedicated India Pavilion consisting of 18 exhibitors.

The presentations were spread across three theatres, namely Manufacturing Insights, Innovation Zone and Workshops and Learning. Examples included 'How PLM can help unlock Digital Transformation in the Automotive Sector' (Sandeep Dinkale, Manufacturing PLM Operations Lead, JRL, Tata Technologies), 'Composite Cross Car Beam: A Case Study in Sustainable Design' (Matthew Atkinson, Lead Research Engineer, Jaguar Land Rover), 'Human Robot Collaboration in Manufacturing: The Future or just Hype?' (Speakers from Airbus Commercial Aircraft, Cranfield University, Fanuc UK and Automate UK), and 'Unlocking the Power of Data and AI for Smarter Manufacturing' (Jesper Toubol, Vice-president Operations, Moulding Production, Lego Group).

SUBCON
THE MANUFACTURING SOLUTIONS SHOW
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In addition the Subcon Magazine Show Guide featured various articles of which 'Machines that think' by Keri Allen (p.34-37) and 'Breaking the Mould' by Jonathan Dyble (p.52-55) may be highlighted for the electronics professional.

The first of these focuses on AI, Machine Learning and Large Language Models and explains how organisations are transitioning from hesitation to digital transformation. Under the heading of 'Trailblazers leading the AI Revolution', Rolls Royce is noted for its use of AI to increase so-called 'time on wing', that is the time an engine is operational and available before it has to be removed for planned maintenance. Lee Glazier, Head of Digital Integrity for Rolls Royce, is quoted as follows:

> *"We currently use AI to create technical insights from the real-time monitoring of more than 3,000 engines at any one time for both reactive and predictive maintenance requirements and also to build a picture of engine characteristics over decades of service and in varying operating conditions.*
>
> *This data picture, created by combining in-engine sensing networks, creating an as-flown digital twin, and using AI, contributes to how we increase time on wing".*

The second article examines how additive manufacturing has evolved from a niche technology limited to prototyping applications into a viable production method across manufacturing sectors from aerospace and automotive to healthcare and industrial tooling. Developments that are discussed include the Tempus technology developed by Renishaw, which synchronises the recoater and laser in laser powder bed fusion systems, enabling the laser to fire while the recoater is in motion, reducing build times by up to 50 per cent. A further development is high-resolution LCD screens driven by the telecoms industry, which allows for very affordable, high accuracy 3D-printing.

Under the heading of 'The Role of AI and Automation', Dr. Max Siebert, CEO and Co-founder of industrial 3D-printing provider Republique, a spinout from BASF, is quoted as follows:

> *" Generative design algorithms are creating optimised structures impossible to conceive through traditional design approaches. These algorithms consider manufacturing constraints from the outset, ensuring designs are not just theoretically optimal, but also producible".*

Innovative laser assignment strategies in conjunction with AM software platforms can also optimise multi-laser systems by reducing energy overlap and laser interference.

Automechanika

Automechanika was located some distance from the other exhibitions making it harder to access, but Manufacturing and Engineering Magazine Issue 535 provided an eight-page feature dedicated to the event beginning with 'Accelerating Innovation: The 2025 Automation Supply Chain Forum unites Industry Leaders for Future Mobility'.

The Automotive Supply Chain Forum was the sixth such Forum, and in partnership with the Society of Motor Manufacturers and Traders (SMMT) was noted for its popular 'Meet the Buyer' Programme where one-to-one meetings were arranged between automotive supply chain suppliers, key Original Equipment Manufacturers and tier-one buyers, and for its new Innovation 4 Mobility element, highlighting the latest advancements and pressing issues within the automotive supply chain.

automechanika

Key topics included developments in hydrogen electrification and battery supply chains, digital transformation and achievements in the field of connected and autonomous vehicles.

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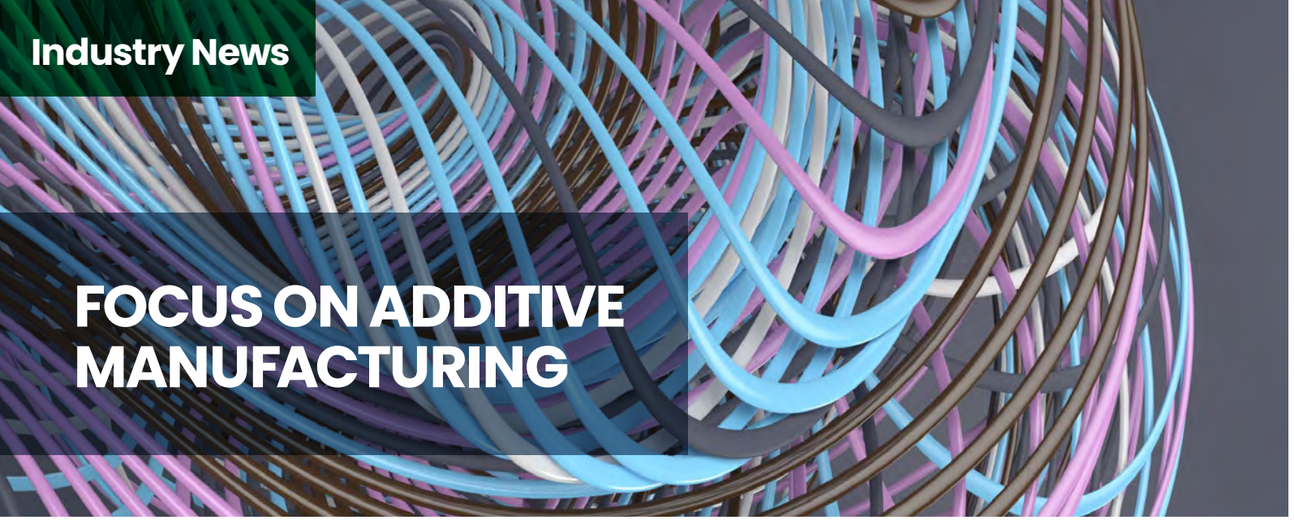

FOCUS ON ADDITIVE MANUFACTURING

Reshaping Product Development with Additive Manufactured Electronics

This article, by Nir Sade, General Manager of Nano Dimension, in the May 2025 issue of Design Solutions (p.26-27) explores how additive manufactured electronics is rapidly emerging as a transformative alternative to traditional prototyping and production techniques.

Additive manufactured electronics are noted particularly for revolutionising R and D in the electronics industry by providing greater freedom of design through geometry, allowing for the creation of smarter and smaller products with integrated non-planar electronics. Designers can simultaneously 3D-print conductive and dielectric materials so as to produce completely new designs, including integrated printed components such as twisted coils, capacitors and any angle connections of conductors. These capabilities simplify assembly and improve signal integrity.

Closely related to this is the ability to rapidly prototype parts in-house, particularly for complex small devices such as antennas and sensors. The use of digital inventories for on-demand, on-site creation of electronics spare parts is also possible, a major benefit when unexpected disruptions prejudice the supply chain.

A further benefit is the ability to rapidly 3D-print cost-effective, multi-layer prototype PCBs, streamlining product development and shortening lead times, removing dependence on external vendors and allowing the simultaneous printing of multiple designs.

Additive manufactured electronics, however, is not without its challenges. It is still at a relatively early stage of industry adoption, and there is still a lack of an established knowledge base for designing 3D-printed electronics, which several universities and research institutes are in the process of addressing along with Nano Dimension:

"Together with the University of Stuttgart and the BMBF Cluster4Future QSens, we are leveraging our multi-layer, multi-material DragonFly IV 3D-printer to accelerate advancements in quantum devices.

To instil trust in the AME offering, we are working with IPC, the global organisation for electronics manufacturing, to develop IPC Standard 2851 - a dedicated standard for the qualification and production of 3D-printed electronics.

We are expecting there to be breakthrough developments in the way AME is used soon, as customers we're working with have already qualified the first applications to be manufactured using the benefits of AME."

3D-printed Electronics accelerate Quantum Sensor Innovation

In a related article entitled 'A Quantum Leap Forward: How 3D-printed Electronics are accelerating Quantum Sensor Innovation at the University of Stuttgart', Oliver Johnson explains in Med-Tech Insights, June 24th., how the BMBF Cluster4Future QSens initiative is pioneering transformation in the field of quantum sensor technology, bridging the gap between academic research and industrial applications.

The author states:

> *"QSens "Quantum Sensors of the Future" - a consortium comprising fifteen industrial partners, the Universities of Stuttgart, Ulm and Tuebingen, the Charite in Berlin, and three research institutions - has set itself the task to pioneer the advancement of quantum research at an unprecedented pace. With the ambitious mission to bring quantum sensors to the market over the next five to nine years, the group sought a solution that would address key challenges and allow for the scalable integration of electronics, photonics and quantum sensor technology, while reducing the time and cost investment that typically restricts accessibility".*

The solution that was adopted was AME with DragonFly IV, which the University of Stuttgart integrated into its research workflow and manufacturing platform Quantum4SME.

This combined additive manufacturing with the ability to print both conductive and non-conductive materials in a single process, provides the ability to create complex multi-layered electronic circuits and, critically, the heterogeneous integration of quantum devices. This enables the creation of specialised quantum devices, such as those used to measure brain activity or nerve signals in med-tech and those used to evaluate atomic structure in chemical engineering.

Leveraging AME drastically streamlines the multiple stages of design, prototyping and testing, resulting in rapid prototyping and immediate testing of new designs, reducing the time and cost of developing and refining quantum sensors.

Now installed in a dedicated research building within the Center for Applied Quantum Technology (ZA Quant) at the University of Stuttgart, the DragonFly IV is allowing experts in quantum physics, photonics and engineering science to collectively leverage its capabilities for applied quantum research:

> *"Within months of installation, the 3D-printer has created a step-change in the pace of research and opened up entirely new interest areas in a number of fields".*

Jasmin Atta of the Institute of Smart Sensors, University of Stuttgart, comments:

> *"Historically, flexible sensors have been extremely difficult to produce. Now, with the help of these 3D-printers, we are able to achieve any kind of pattern, any kind of design".*

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Improving Metal 3D-printing

Metal additive manufacturing uses a high-powered laser to selectively fuse fine metallic powder so as to build parts layer by layer from a precise 3D model, creating complex, highly customised components with minimal material waste. It is frequently hindered, however, by the hitherto high cost of having to determine optimal process parameters by trial and error.

Now, researchers at the University of Toronto have developed a new framework known as the Accurate Inverse Process Optimisation Framework in Laser Directed Energy Deposition (AIDED) that quickly identifies the optimal process parameters for the application required.

A closed-loop system uses a generic algorithm that mimics natural selection to determine optimal solutions. This first suggests combinations of process parameters and then applies machine learning to evaluate printing quality. The algorithm then verifies these predictions iteratively until the best parameters are found.

Numerous experiments were conducted to collect vast data set with the aim of developing an enhanced autonomous, or 'self-driving' additive manufacturing system.

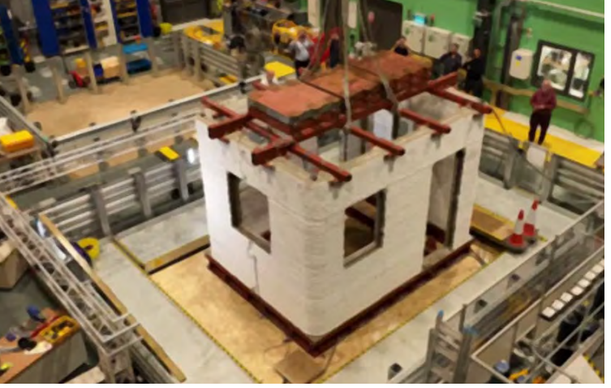
First Author of the study Xiao Shang, states:

> *"We have demonstrated that our framework can identify optimal process parameters from customisable objectives in as little as one hour, and accurately predicts geometries from process parameters. It is also versatile and can be used with various materials".*

Yu Zou, Professor of Materials and Engineering in the Faculty of Applied Science and Engineering at the University of Toronto, adds:

> *" By combining cutting-edge additive manufacturing methods with artificial intelligence, we aim to create a novel closed-loop controlled self-driving laser system. This system will be capable of sensing potential defects in real-time, predicting issues before they occur and automatically adjusting process parameters to ensure high quality production. It will be versatile enough to work with different materials and part geometries, making it a game-changer for manufacturing industries".*

Reference: 'AIDED Framework for Metal 3D-printing', International Sheet Metal Review, Vol.25, No.5, June 2025, p.19



Earthquake Simulation Stress Tests 3D-printed Concrete House

Scientists at the University of Bristol have deployed the UK's largest shaking table to simulate the effects of a medium-magnitude earthquake on a 3D-printed concrete house.

Traditional concrete structures have well-established seismic resilience, but 3D-printed concrete structures introduce new variables such as layered deposition, unique material properties and unique geometries.

Testing used a high-end shaking table capable of holding up to 50 tonnes and of simulating the ground motions representative of a real earthquake. The house was created using a robotic additive manufacturing process with controlled material deposition and geometry, and incorporated accelerometers, displacement sensors and various gauges designed to capture a comprehensive set of dynamic response data.

In the test the unit was subjected to increasing intensity ground motion with each test sequence allowing for real-time assessment of cracking, displacement and potential failure points. The resultant data then enabled evaluation of the structured resilience of the 3D-printed unit, allowing for comparison of its performance relative to traditional construction methods and validation of computational models that are used as predictors of seismic behaviour.

Project Lead Dr. Raffaele De Risi states:

> *"Insights from this study will help identify design parameters that optimise seismic performance, such as layer bonding strategies and reinforcement integration.*
>
> *Ultimately we hope to validate whether 3D-printed concrete can meet current safety standards for seismic applications and provide a foundation for developing building codes that include additive manufacturing technologies.*
>
> *By testing the seismic resilience of 3D-printed concrete for the first time, we're not just exploring the future of construction, we're helping shape a safer, smarter and more adaptive built environment".*

Reference: West, P., Electronic Specifier, 18th. June

Multiphoton 3D Lithography produces minute Replica of Sorbonne University Chapel

An advanced laser nanofabrication technique known as multiphoton 3D lithography has been used to produce a minute replica of Sorbonne University Chapel.

The replica, the length of which is approximately 120 micrometres, and which is around 275,000 times smaller than the real chapel, was produced by Dr. Gordon Zyla, a senior researcher at the Vilnius University Faculty of Physics. With all of the intricate architectural details of the original preserved, it was gifted to the President of Sorbonne University, Professor Nathalie Drach-Temam during a high-level delegation visit.

Dr. Zyla explains how this advanced form of 3D-printing operates:

> *"Unlike conventional 3D-printing, this approach can solidify a light-sensitive material at virtually any point in space, enabling the fabrication of truly three-dimensional structures. Interestingly, by using a sharply-focused ultrashort-pulse laser beam, it is possible to initiate a polymerisation reaction with such precision that it creates spatial elements, or voxels, just a few hundred nanometres in size. For comparison, a human hair is about 80 micrometres thick, roughly 500 times wider than the structures created by this method.*
>
> *Simple spherical microelements - six times smaller than the chapel - can improve the resolution of optical microscopes beyond what standard lenses can achieve. Other tiny structures, carefully arranged in patterns, can shape and control light in new ways to enable novel interactions with matter. This may open up possibilities for future applications in bio-imaging, quantum technologies, telecommunications and laser technologies".*

Reference: Miles, S., 'Vilnius University's Gift to Sorbonne University President', Electronic Specifier, 1st. July

First Testing Facility for testing Materials 3D-printed in Space

The world's first dedicated facility for testing the structural integrity of materials that are 3D-printed in space has been constructed at the University of Glasgow's James Watt School of Engineering.

The NextSpace Testrig uses a specially constructed vacuum chamber that can generate temperatures from -150 to +250 degrees Centigrade, recreating space-like conditions on Earth, and features an automatic magazine system that can autonomously test multiple samples in a single cycle, making it significantly more efficient than traditional testing methods. The system can apply up to 20kN of force (equivalent to 2000 kg) to break samples and analyse their properties under vacuum conditions similar to those in space, and subject samples to cycles of extreme temperature.

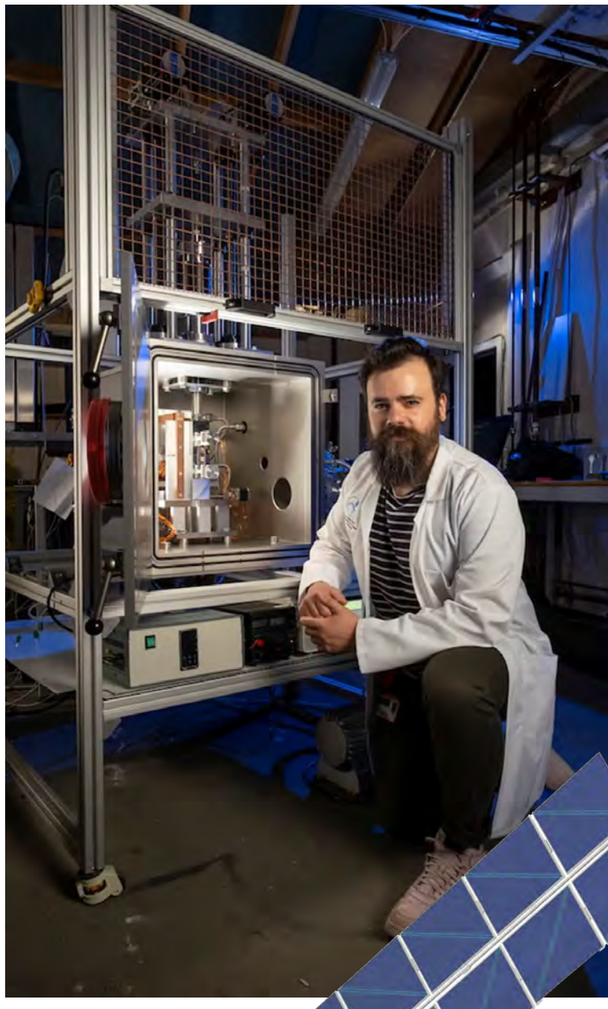
Prototype 3D-printers have already been sent into orbit and metal parts have been 3D-printed on board the International Space Station, but so far no research facility has ever been dedicated to ensuring that polymers, ceramics and metals that are printed in space will be able to withstand the physical strains that they will face.

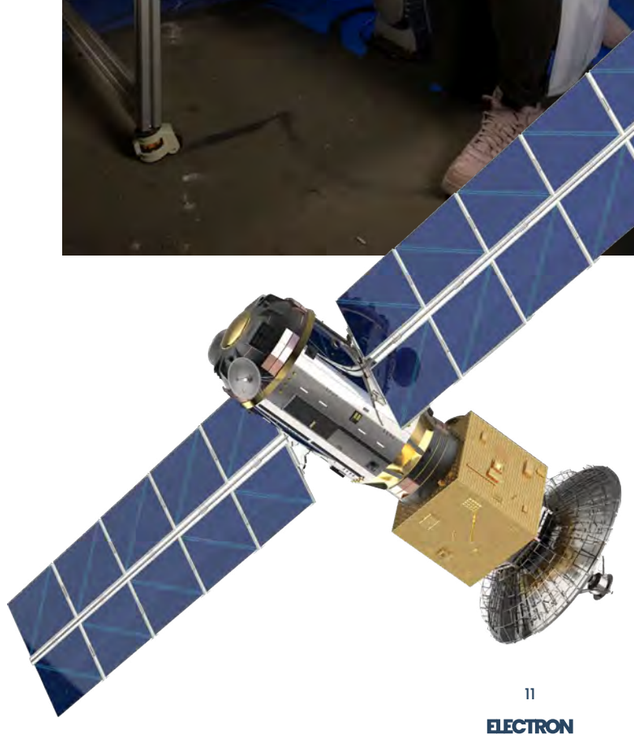
Imperfections such as tiny bubbles or poorly melted sections that may be inconsequential on Earth could have serious effects in space, such as shattering, scattering hazardous fragments.

Dr. Gilles Bailet, who developed the NextSpace Testrig in partnership with The Manufacturing Technology Centre, states:

> *" 3D-printing is a very promising technology for allowing us to build very complex structures directly in orbit instead of taking them into space on rockets. It could enable us to create a wide variety of devices, from lightweight communications antennas to solar reflectors to structural parts of spacecraft or even human habitats for missions to the Moon and beyond.*
>
> *However, the potential also comes with significant risk, which may be magnified if efforts to start 3D-printing in space are rushed out instead of being properly tested. Objects move very fast in orbit, and if a piece of a poorly made structure breaks off it will end up circling the Earth with a velocity of a rifle bullet. If it hits another object like a satellite or spacecraft, it could cause catastrophic damage, as well as increase the potential of cascading problems as debris from any collisions cause further damage to other objects.*
>
> *The NextSpace Testrig is open to academic colleagues, researchers and commercial clients from around the world to help them ensure that any materials they plan to 3D-print in space will work safely. We also expect that the data we'll be gathering in the years to come, which can't be replicated anywhere in the world at the moment, will help regulatory authorities to make safety standards for in-space manufacturing informed by real-world testing".*

Reference: 'First-of-its-kind Test Facility could help Space Industry dodge a Bullet', Instrumentation Monthly, May 2025, p.5





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MORE DEVELOPMENTS IN QUANTUM COMPUTING

Superconductor Prototyping for Critical Technologies

The University of Glasgow has received a £1.5 million grant from the UKRI Engineering and Research Council (EPSRC) for its three-year Superconducting Prototyping for Critical Technologies (Super-CT) project to support the development of more efficient superconductors, which will help accelerate advances in quantum technologies.

The project brings together researchers from Glasgow University's James Watt School of Engineering and university spinout Quantcore to construct the UK's first fabrication facility for niobium-based superconducting circuits for use in quantum computing devices.

Niobium circuits offer numerous advantages over the traditional aluminium type, which can be affected by external noise. The niobium circuits notably operate more reliably and at faster clock rates with lower power consumption.

The pioneering foundry will examine how the circuits can be built and scaled up from single chips to larger scale manufacturing on silicon wafers, which is a key step towards being able to produce the circuits on a commercial scale.

Project Leader Professor Martin Weides says:

> *"Superconductors are the foundation on which the technologies of the future will be built. Quantum computers, sensors and communications all rely on superconducting circuits operating at very low temperatures."*

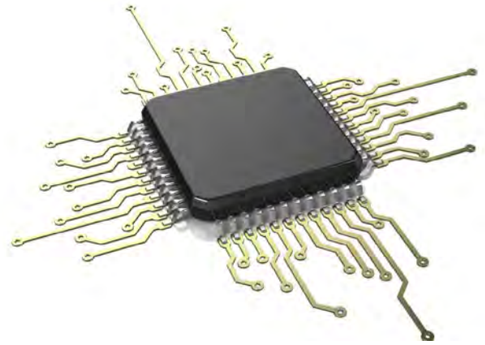
Scotland's central belt is home to a unique concentration of expertise across the cutting-edge technologies which will enable the quantum devices of the future. We can handle everything from fundamental research to prototype development at the James Watt Nanofabrication Centre and ultimately to commercial fabrication.

This new funding from EPSRC to help establish Super-CT will help drive breakthrough advances in niobium-based superconductors. It will unlock new capabilities in quantum systems, help build the strength of the UK's cutting-edge supply chain, and further establish Scotland as a key driver for the technologies of the future.

Reference: West, P., '£1.5m Boost will deliver Quantum Leap for Superconductor Manufacturing', Electronic Specifier, 19th. June

Scalable Production of World's First Quantum-powered Universal Memory

IQE, a commercial supplier of compound semiconductor wafer products and advanced material solutions, has successfully completed a project to develop scalable production of ULTRARAM, the world's first quantum-powered universal memory, in collaboration with Quinas Technology and Lancaster and Cardiff Universities.



In the project IQE successfully scaled up the manufacture of compound semiconductor layers initially developed by Lancaster University into a complete industrial process, completing the first step towards the commercial production of packaged ULTRARAM chips. IQE has notably pioneered an advanced capability in gallium antimonide and aluminium antimonide epitaxy, which represents a world first for scalable epitaxy for memory devices.

ULTRARAM is a dual-use technology that was invented at Lancaster University, combining the non-volatility of a data storage memory, such as flash, with the speed and endurance of a working memory such as DRAM, while providing significantly improved energy efficiency. It is envisaged to have a pivotal role in areas such as artificial intelligence, quantum computing, space and defence.

Jutta Meier, Chief Executive Officer of IQE, states:

> *"We have successfully achieved our goal of developing a scalable epitaxy process for ULTRARAM, a milestone towards industrial production of packaged chips. This project represents a unique opportunity to bring the next generation of compound semiconductor materials to life in the UK, and we are proud of our work with Quinas, Lancaster and Cardiff Universities to advance commercial production and create world-leading universal memory devices".*

James Ashforth-Pook, Chief Executive Officer of Quinas Technology, adds:

> *"This project marks a turning point in the journey from university research to commercial memory products. With IQE's industrial capabilities and Innovate UK's support, we have taken a critical step toward building sovereign capability in memory - the most strategically vital yet underrepresented segment of the UK semiconductor stack".*

Reference: Tyler, N., 'IQE and Quinas Technology complete £1.1m ULTRARAM Industrialisation Project', New Electronics, 17th. June

Cork Scientists pioneer Method for identifying Quantum Materials

Scientists at University College Cork have developed a new technique for identifying materials for the next generation of large scale, fault-tolerant quantum computers.

For the first time it has become possible to determine absolutely whether a material possesses the intrinsic properties required for certain types of quantum computing chips.

The team focused specifically on the compound uranium ditelluride, a superconductor already considered for topological quantum computing, and at the heart of the research was a series of experiments that used a variant of highly specialised tunnelling microscopy, STM, known as Andreev STM, which is only available at University College Cork, Oxford University and Cornell University.

Andreev STM was used to examine the quantum properties of uranium ditelluride using a superconducting probe rather than the more conventional metal tips, which allowed the team to isolate and observe critical particles known as Majorana fermions, on the material's surface. This provided an important validation for this probing method.

Microsoft has recently released the world's first Quantum Processing Unit powered by a 'Topological Core' using synthetic topological superconductors assembled from layered conventional materials. Now, the findings from Cork are envisaged to open the door to identifying materials that could effectively replace otherwise complex architectures, enabling

improved energy efficiency, simplification of chip design, and application of higher qubit density.

One of the leaders of the study, PhD researcher Joe Carroll, comments:

> *" Traditionally researchers have searched for topological superconductors by taking measurements using metallic probes. What's new about our technique is that we use another superconductor to probe the surface of uranium ditelluride. By doing so we exclude the normal surface electrons from our measurement, leaving behind only Majorana fermions".*

Reference: West, P., Electronic Specifier, 30th. June

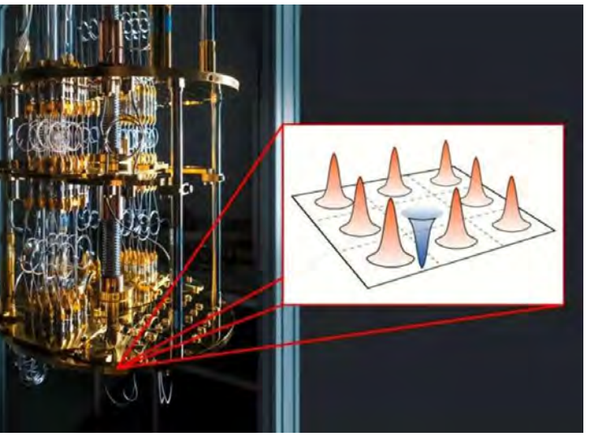
World First Method of error-correctable Quantum Computers Simulation

Researchers at Chalmers University of Technology in Sweden, the University of Milan, the University of Granada and the University of Tokyo have revealed a method for simulating specific types of error-corrected quantum computations, marking a significant advance in quantum technology.

In order to verify the accuracy of a quantum computation the calculations are simulated using conventional computers, and one particularly important type of quantum computation that is of interest is the type that can withstand disturbances and effectively correct errors. The immense complexity of quantum computations, however, makes simulation especially difficult.

Now, a method has been devised for accurately simulating a certain type of quantum computation that is particularly suitable for error correction, but which so far has been extremely difficult to simulate.

The hitherto limited ability of quantum computers to implement error correction is a function of their fundamental building block i.e. the qubit. Qubits have immense computational power, but are also highly sensitive and therefore susceptible to disturbance.



In order to counteract this susceptibility error correction codes are introduced to distribute information across multiple subsystems so as to allow errors to be detected and corrected without destroying the quantum information. One way of doing this is to encode the quantum information of a qubit into the multiple or possibly even infinite energy levels of a vibrating quantum mechanical system, a method known as bosonic coding. Until now, however, this method has been prone to unreliability due to the multiple energy levels, which are difficult to simulate with conventional computers.

With the new method an algorithm is used that is able to simulate quantum computations that use a specific kind of bosonic code known as the Gottesman-Kitaev-Preskil, or GKP, code. This is commonly used in leading implementations of quantum computers and the team was able to use the code in their algorithm by creating a new mathematical tool.

Cameron Calcluth, First Author of the study, states:

> *"We have discovered a way to simulate a specific type of quantum computation where previous methods have not been effective. This means that we can now simulate quantum computations with an error correction code used for fault tolerance, which is crucial for being able to build better and more robust quantum computers in the future.*
>
> *The slightest noise from the surroundings in the form of vibrations, electromagnetic radiation, or a change in temperature can cause the qubits to miscalculate or even lose their quantum state, their coherence, thereby losing their capacity to continue calculating".*

Co-author of the study, Giulia Ferrini, Associate Professor of Applied Quantum Physics at Chalmers University, adds:

> *"The way it [the GKP Code] stores quantum information makes it easier for quantum computers to correct errors, which in turn makes them less sensitive to noise and disturbances. Due to their deeply quantum mechanical nature, GKP Codes have been extremely difficult to simulate using conventional computers. But now we have finally found a unique way to do this much more effectively than with previous methods.*
>
> *This opens up entirely new ways of simulating quantum computations that we have previously been unable to test but are crucial for being able to build stable and scalable quantum computers".*

Reference: Miles, S., Electronic Specifier, 3rd. July

RECONFIGURABLE OPTICAL DEVICE FOR LIGHT-BASED COMPUTING

Engineers at the John and Marcia Price College of Engineering have pioneered the development of a new device that can dynamically control the circular polarisation of light, a property that enables the encoding and storage of information, offering a pathway towards more compact and efficient optical circuits.

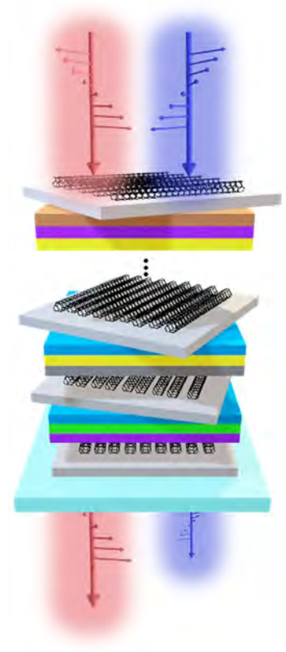
The new device has been likened to "living optical matter" which responds in real-time to electrical pulses. At its heart is a carefully engineered heterostructure that is composed of multiple stacked thin films, including a layer of carbon nanotubes aligned in varying directions which serve the dual functions of manipulating the 'chirality' of light and the conduction of electrical signals. These signals trigger a phase-change material (PCM) layer to transition between amorphous and crystalline states. This structural change affects the degree to which the material absorbs left or right circularly polarised light, known as circular dichroism. This property was able to be finely controlled across a full wafer following improvements in the scalable fabrication of both the aligned carbon nanotubes and the PCM layers.

Once integrated the heterostructure selectively filters circularly polarised light depending on the state of the PCM. Crucially, this process is reversible and electrically tuneable, allowing real-time control over the optical behaviour of the device. This opens the door to encoding information based on the "handedness" (left or right) of polarised light, potentially creating new channels for optical memory and computation.

PhD student Jichao Fan comments:

> *" We've created 'living' optical matter that evolves with electrical pulses, thanks to our aligned-carbon-nanotube-phase-change-material heterostructure that merges light manipulation and memory into a single scalable platform.*

The carbon nanotubes simultaneously act as chiral optical elements and transparent electrodes for PCM



switching - eliminating the need for separate control components".

Assistant Professor Weilu Gao of the Department of Electrical and Computer Engineering adds:

> *" Traditional chiral optics were like carved stone - beautiful but frozen. This made them not useful for applications requiring real-time control, like reconfigurable optical computing or adaptive sensors.*
>
> *By adding circular dichroism as an independent parameter, we create an orthogonal information channel. Adjusting it does not interfere with other properties like amplitude or wavelength".*

Reference: West, P., 'Researchers create reconfigurable Optical Device for Light-based Computing', Electronic Specifier, 7th. July

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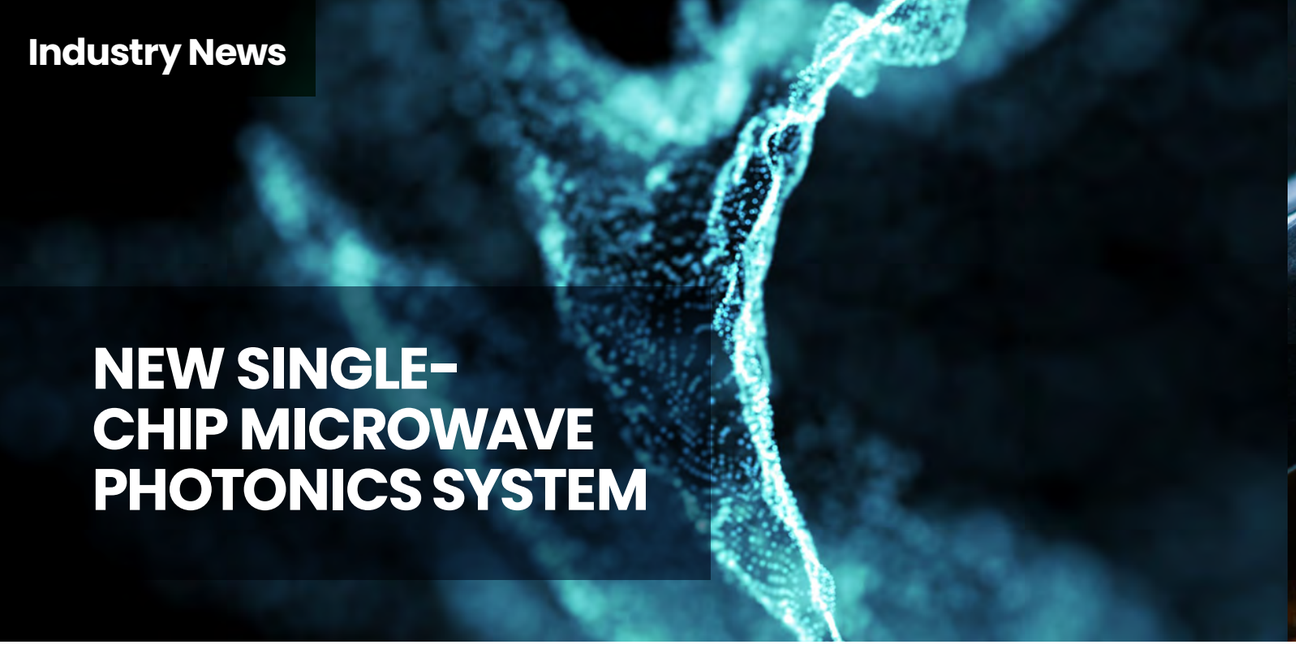


NEW SINGLE-CHIP MICROWAVE PHOTONICS SYSTEM

The Photonics Research Group and IDlab, two imec research groups at Ghent University, have developed, with the help of imec itself, a fully integrated single-chip microwave photonics system that combines optical and microwave signal processing on a single silicon chip.

The chip integrates high-speed modulators, optical filters, photodetectors and transfer-printed lasers, making it a compact, self-contained and programmable solution for high-frequency signal processing. This enables bulky and power-hungry components to be potentially replaced, allowing for faster wireless networks, low-cost microwave sensing and scalable deployment in applications such as 5G/6G, satellite communications and radar systems.

Modern communications rely on high-speed fibre-optic links and wireless radio-frequency microwave transmission, but with increasing demand for higher data rates and operation at higher frequencies, the need for tighter integration between these to offset signal processing complexity, high transmission losses and power-hungry electronics is greater than ever

Microwave photonics has been identified as a promising solution with optical technology deployed to process high-frequency signals with lower loss, higher bandwidth and improved energy efficiency. Most present-day systems, however, still rely on bulky fibre-based architectures that have limited scalability.

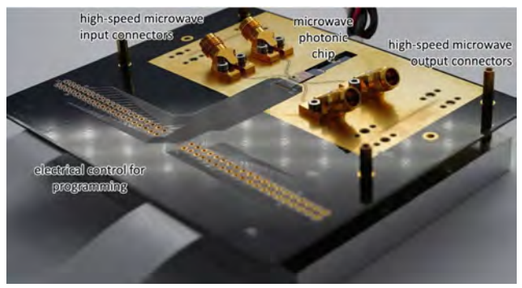
The new system deploys a novel combination of a reconfigurable modulator and a programmable optical filter that enables efficient modulation and filtering of microwave signals while significantly reducing signal loss.

The chip is built on imec's standard iSiPP50G silicon photonics platform, which includes low-loss waveguides and passive components, high-speed modulators and detectors, and thermo-optic phase shifters for tuning the optical response. An indium phosphide optical amplifier is incorporated on the chip to provide an integrated light source, achieved as a result of a microtransfer-printing process developed by the Photonics Research Group. In combination with on-chip tuneable filter circuits, this allows the optical amplifier to function also as a tuneable laser.

Wim Bogaerts, Professor at the Photonics Research Group, states:

> *"The ability to integrate all essential microwave photonics components on a single chip marks a major step toward scalable and energy efficient high-frequency signal processing. By eliminating bulky external components, this technology paves the way for more compact, cost-effective solutions in next-generation wireless networks and advanced sensing systems".*

Reference: Miles, S., 'imec and Ghent unveil Single-chip Microwave Photonics System', Electronic Specifier, 5th. June



FIRST 2D COMPUTER CHALLENGES DOMINANCE OF SILICON

Researchers at Penn State University have, for the first time, used 2D materials to develop a complementary metal-oxide semiconductor (CMOS) without reliance on silicon.

Two different 2D materials were used to develop both types of transistors needed to control the electric current flow, namely molybdenum disulphide for the n-type transistors and tungsten diselenide for the p-type transistors.

Metal-organic chemical vapour deposition (MOCVD), a fabrication process that involves vapourising ingredients, was used to force a chemical reaction and deposit the products onto a substrate so as to grow large sheets of molybdenum disulphide and tungsten diselenide and fabricate over a thousand of each transistor type.

By carefully tuning the device fabrication and post-processing steps, it was possible to adjust the threshold voltages of both the n-type and p-type transistors to enable the construction of fully functional CMOS logic circuits.

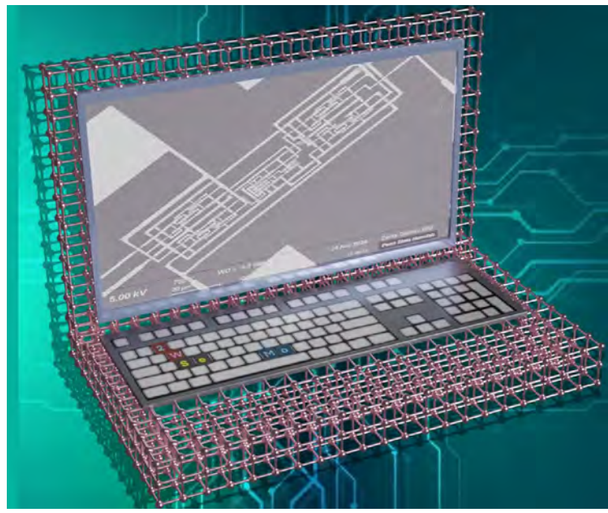
Saptarshi Das, Ackley Professor of Engineering and Professor of Engineering Science and Mechanics at Penn State University, says:

> *"We have demonstrated, for the first time, a CMOS computer built entirely from 2D materials, combining large area grown molybdenum disulphide and tungsten diselenide transistors.*
>
> *We expect that the development of 2D material computers is going to be a gradual process, but this is a leap forward compared to the trajectory of silicon".*

First Author Subir Ghosh adds:

> *"Our 2D CMOS computer operates at low-supply voltages with minimal power consumption and can perform simple logic operations at frequencies up to 25 kilohertz.*
>
> *We also developed a computational model, calibrated using experimental data and incorporating variations between devices, to project the performance of our 2D CMOS computer and benchmark it against state-of-the-art silicon technology. Although there remains scope for further optimisation, this work marks a significant milestone in harnessing 2D materials to advance the field of electronics".*

Reference: Gittins, C., Electronic Specifier, 15th. June



DEVELOPMENTS IN AI APPLICATIONS

Isambard-AI goes live in Bristol

The UK's most powerful supercomputer, Isambard-AI, is now operational at the University of Bristol.

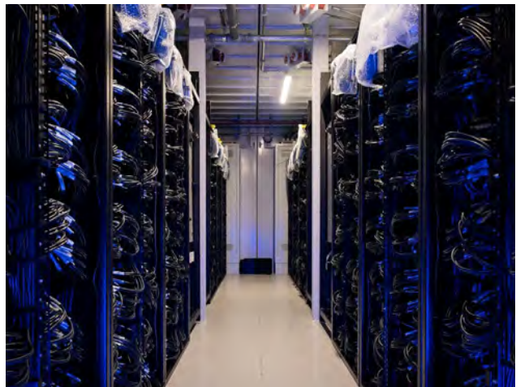
It will be used in conjunction with Dawn, a similar but smaller supercomputer in Cambridge, to create a national AI backbone for scientific research.

Applications include:

- Analysing MRI scans to detect early signs of Cancer
- Modelling protein structures to discover drugs faster
- Interpreting video data from wearable devices to improve support for dementia
- Monitoring livestock to detect early warnings of disease

It will also support the UK's AI Safety Institute, helping to assess and mitigate risks associated with so-called frontier AI technologies such as biothreats and cybercrime.

Housed at the National Composites Centre at the Bristol and Bath Science Park, Isambard-AI was built using 5,400+ NVIDIA GH200 Grace Hopper Superchips and is the world's eleventh most powerful supercomputer. It was constructed using low-carbon modular parts and aims to incorporate waste recycling to support local heating needs. It ranks fourth globally on the Green500 list of the world's most energy efficient supercomputers.



Reference: Cappella, N., 'UK's most advanced Supercomputer Isambard-AI goes live in Bristol', Data Centre World, 25th. July

Breakthrough AI-equipped MCUs

The first MCU capable of predicting equipment anomalies via on-device learning and inference without a network has been launched by ROHM.

The device enables fault prediction and degradation forecasting using sensing data of various kinds, such as that from industrial equipment like motors.

Equipment manufacturers are increasingly seeking solutions that allow real-time monitoring of operational status while avoiding the drawbacks of network latency and security risks. Standard AI processing models, however, typically depend on network connectivity and high-performance CPUs, which can be costly and difficult to install.

In order to help address this, ROHM has developed groundbreaking AI MCUs that allow stand-alone AI learning and inference directly on the device. These deploy a simple three-layer neural network algorithm implementing ROHM's proprietary on-device AI solution known as Soloist-AI™, enabling the MCUs to perform learning and inference independently without the need for cloud or network connectivity.

Incorporating a 32-bit Arm® Cortex®-MO+ core, CAN FD controller, 3-phase motor control PWM and dual A/D converters, and achieving a low power consumption of 40mW, they are said to be ideally suited for fault prediction and anomaly detection in industrial equipment, residential facilities and home appliances.

ROHM has also released an AI simulation tool (Soloist-AI™ Sim) on its website, allowing users to evaluate the effectiveness of learning and inference prior to deployment of the AI MCU. The data so generated may then be used as training data for the AI MCU, supporting pre-implementation validation and improving inference accuracy.

ABB launches Gen-AI Vault

ABB has launched a generative AI-driven tool to prevent knowledge from being lost in industrial environments.

The Industrial Knowledge Vault can store and safeguard critical expertise, while transforming that knowledge into step-by-step workflows, allowing workers to access and apply best practices. It learns continuously from real-world applications, refining workflows and best practices in order to drive continuous improvement. By integrating with existing industrial systems it enhances collaboration between field workers and control rooms providing real-time visibility into job status and operational procedures, which can reduce bottlenecks and improve overall process functioning.

As experienced employees retire, the loss of their decades of knowledge threatens operational continuity, efficiency and innovation. Traditional documentation is typically fragmented, requiring significant manual effort to compile, interpret and apply. The Industrial Knowledge Vault addresses this by capturing and structuring expertise in a secure central repository that can be accessed using natural language conversations.

Structural procedures can be created in seconds, eliminating the need to parse documents manually.

The Industrial Knowledge Vault uses ABB's Genix CoPilot in conjunction with Microsoft's Azure OpenAI to analyse and synthesise information into actionable procedures.

ABB's Global Head of Digital for Process Industries, Sanjit Shewale, states:

> *"Industries everywhere are facing a critical knowledge gap as a generation of experienced workers retire and take their invaluable expertise with them. Our Industrial Knowledge Vault tackles this challenge head on by providing a secure and accessible platform to enable businesses to do more with digital. By capturing, preserving and sharing this vital knowledge, businesses can ensure operational continuity and empower workforces with in-the-moment information to perform their jobs smarter, faster and more sustainably".*

Reference: 'Gen-AI Vault will preserve Knowledge from Industry Experts', Drives and Controls, May 2025

World First for Largest Coral Reef Restoration Programme

The King Abdullah University of Science and Technology (KAUST) in partnership with digiLab is developing an AI-embedded digital twin platform to support its KAUST Coral Restoration Initiative, the world's largest coral restoration project.

The AI solutions are designed to tackle critical aspects of coral resilience, such as thermal tolerance and growth, reducing the time required for coral assessments and increasing the accuracy of data that can be retrieved from environmental stressors such as temperature and light. They will help scientists to closely simulate and predict the behaviour of the real-world reefscape in real-time, identifying factors such as algae growth and signs of disease.

The project focuses notably on the restoration and enhancement of coral reefs through a large-scale coral nursery system to support coral propagation and natural reproduction, with KAUST planning to plant two million corals around the reefscape by 2030. At peak capacity, the sea-based nurseries should produce 100,000 corals a year, with the primary land-based nursery producing about 400,000.

An innovative sensor placement system will augment data collection, with machine learning being used to assess optimal sensor placement.

Professor Dave Suggett, Director of the KAUST Restoration Initiative, states:

> *" The KAUST Coral Restoration Initiative represents a significant step towards more effective restoration of reefs globally. By partnering with digiLab to develop an AI-enabled digital twin of the reefscape, we are pioneering innovative approaches to upscale coral management efforts, including restoration decision-making. This collaboration allows us to leverage cutting-edge AI technology to monitor, predict and optimise our restoration strategies in real-time, potentially revolutionising how we approach coral reef conservation on a global scale".*

Co-founder of digiLab, Anhad Sandhu, adds:

> *" digiLab's partnership with KAUST on the world's largest coral restoration project marks a significant milestone in the application of AI technology to solve the world's challenges. digiLab is supporting revolutionary methods for coral reef monitoring and restoration by developing these AI models for the reefscape's digital twin".*

Reference: Wood, A., Electronic Specifier, 2nd. July

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NEW DIGITAL TWIN CENTRE OPENS IN BELFAST

A new £37.5 million Digital Twin Centre has opened in Belfast with the aim of driving the next wave of industrial transformation by accelerating the adoption of digital twin technologies.

The Centre will help businesses throughout the UK to demonstrate and deploy digital twins, bringing together capabilities specifically in intelligence, data services, immersive and user experiences, cyberphysical systems, integration and security.

There are three co-investing industrial partners, namely Artemis Technologies, Spirit AeroSystems and Thales UK, with the Centre being delivered the Digital Catapult.

The Centre's first six-month accelerator programme will support partnerships between technology, SMEs and industry to fast track digital twin adoption in the maritime, aerospace and defence sectors.

Participants will be assisted with funding from Innovate UK as well as mentorship, workshops and support to develop proofs-of-concept in areas such as IoT, data integration and simulation tools.

Susan Bowen, CEO of Digital Catapult, says:

> *"The UK Digital Twin Centre brings together our technical expertise, facilities and networks to unlock the power of deep technologies. By connecting industries with cutting-edge technology through our programmes, we are enabling businesses to harness the full potential of digital twins - driving operational efficiencies, advancing sustainability and sharpening the competitive edge of UK businesses".*

Reference: 'UK's £37m Digital Twin Centre opens to drive Digitalisation', Drives and Controls, June 2025, p.6

PASSIVE COOLING BREAKTHROUGH FOR DATA CENTRES

Engineers at the University of California San Diego have developed a new passive cooling technology for data centres that utilises a specially designed fibre membrane capable of removing heat through evaporation without any requirement for additional energy input.

Unlike conventional methods of heat removal, such as fans, heat sinks and liquid pumps, this method uses the natural capillary action of a porous membrane to draw cooling liquid across its surface. This then evaporates drawing heat from the underlying electronics.

The membrane contains a network of small, interconnected pores that optimise fluid flow and surface area for evaporation. It is positioned over microchannels that transport coolant underneath the membrane's surface.

Previous attempts to use porous membranes for high-power electronics have tended to fail due to incorrect pore sizing. If the pores are too small the pores clog, whereas if they are too large boiling can result. Now, porous fibre membranes have been deployed with interconnected pores with the correct sizing.

Testing under various thermal conditions showed that the membrane can handle over 800 Watts per square centimetre of heat, which is among the highest recorded for this type of passive cooling system. It also remained stable over several hours of continuous operation.

With these results still well below the theoretical operating maximum, the team is now working on enhancing the membrane's efficiency with the aim of developing prototype cold plates that can be attached directly onto CPUs and GPUs and a startup has been established to commercialise the technology.

Professor Renkun Chen of the Department of Mechanical and Aerospace Engineering at the University of California San Diego Jacobs School of Engineering, explains:

> *"Compared to traditional air or liquid cooling, evaporation can dissipate higher heat flux while using less energy.*
>
> *This success showcases the potential of reimagining materials for entirely new applications. These fibre membranes were originally designed for filtration, and no-one had previously explored their use in evaporation. We recognised that their unique structural characteristics - interconnected pores and just the right pore size - could make them ideal for efficient evaporative cooling. What surprised us was that, with the right mechanical reinforcement, they not only withstood the high heat flux - they performed extremely well under it".*

Reference: West, P., 'Engineers unveil Passive Cooling Breakthrough for Data Centres', Electronic Specifier, 14th. July

BREAKTHROUGH IN OFFSHORE WIRELESS COMMUNICATIONS

Ashtead Technology has set a new benchmark in advanced wireless communication and private network connectivity for offshore applications.

Building on the established Seatronics SeaMESH, AT-MESH achieves broadband speeds of up to 87Mbps, greatly exceeding the 8.9Mbps previously achieved. Utilising multiple-input, multiple-output (MIMO) mesh technology, it offers low-latency to achieve real-time data transmission. Connectivity up to 30km with clear line of sight guarantees reliable performance.

The high-bandwidth capabilities support up to 144 nodes at 22Mbps or 24 nodes at 87Mbps, allowing the technology to be deployed across a range of applications including multi-vessel resource sharing, vessel data exchange, pipeline monitoring, remotely operated vehicle and diving operations, and tug management.

AT-MESH is said to be the first system to have built-in capability to wirelessly transmit high-definition serial digital interface video between vessels, eliminating the need for dedicated encoder modules.

Conventional radio frequency data telemetry systems only offer point-to-point connections, whereas AT-MESH enables data sharing across multiple nodes. Serial data transmission is also possible by incorporating a serial server.

The system has been described as " a game-changer in offshore connectivity".

Reference: 'Ashtead advancing Offshore Communication Technology', NDT News, May 2025, p3

IMPROVING INSPECTION OF PLASTIC INJECTION MOULDING

Plastic injection moulding has traditionally posed challenges when it comes to quality control. The speed of production and the complexity of mould designs creates vulnerability to warping, sink marks and voids. Consequently there is an interest in having a system that can detect these defects as soon as the part exits the mould.

Now, TheyeQ in Annecy, France, has come up with a solution, namely TheEye, an innovative camera-based system which can detect defects in a wide range of manufactured products.

The key innovation is the combination of polarimetric and thermal imaging technologies. Unlike conventional systems that often rely on high-definition cameras, this system uses polarimetric imaging to detect surface stress and defects that are invisible to the human eye, whilst thermal imaging detects variations in heat distribution that can reveal potential issues related to cooling and material flow. The result is 'an unparalleled level of defect detection'.

Polarimetric imaging captures information about the orientation of light waves as they reflect off a surface , highlighting surface irregularities and stresses, whilst thermal imaging reveals heat signatures, which can be an indicator of cooling defects, temperature inconsistencies and flow anomalies in the moulding process.

These two imaging methods combined provide a multidimensional view of the part, and with AI-driven analysis, allow for rapid and accurate assessments of part quality. The AI evaluates multiple images, identifying deviations and defects while learning to improve its accuracy over time through deep learning. A continuous learning loop is thus created which ensures that the system becomes more effective as it gains exposure to different parts and defect patterns.

TheEye captures and analyses images in milliseconds, with each inspection taking place in just 60 milliseconds. The AI algorithms were optimised so as to achieve the optimum balance between speed and accuracy.

Reference: Davies, N., 'Keeping an Eye out for Trouble', Engineering Designer, January-March 2025, p.20-23

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FOCUS ON SPACE

Robots set to build Infrastructure in Space

The United Kingdom Atomic Energy Authority (UKAEA) and space-tech company Space Solar have demonstrated that robots could build infrastructure in space without human intervention.

The AlbaTRUSS project, conducted at the UKAEA advanced test facility at Culham in Oxfordshire, showed that remotely operated dual-arm robotic manipulators were able to guide robots to assemble gigawatt-scale solar power satellites, paving the way for robots to assemble infrastructure such as data centres in orbit.

Space Solar aims to harness abundant solar energy in space and beam it back to Earth using satellites consisting of hundreds of thousands of modular units assembled into structures 20 metres wide and several kilometres in length. AlbaTRUSS as a proof-of-concept project has shown that robots could be used to assemble a scaled structural truss bay or 'longeron' tubing, which forms a core element of the satellite's framework.

Space Solar selected the UKAEA Centre for Remote Applications in Challenging Environments because fusion and space robotics have a number of things in common, in particular the fact that neither require oxygenated environments and both can function in varying degrees of radiation. Together they have the potential to provide constant, low-carbon baseload energy around the world.

Dr. Sam Adlen, Co-COE of Space Solar, comments:

> *"The AlbaTRUSS project is a milestone not just for our satellite architecture, but for the future of large-scale structures in space, from data centres to energy infrastructure.*
>
> *Up in space, the Sun shines 24/7. Once constructed, these satellites capture solar power and beam it back down to Earth in the form of microwaves, which can be received by antennas on the ground and converted into electricity for the grid.*
>
> *The achievement opens up new horizons for the space sector, an adjacent economic sphere that can ensure a bright future here on Earth".*

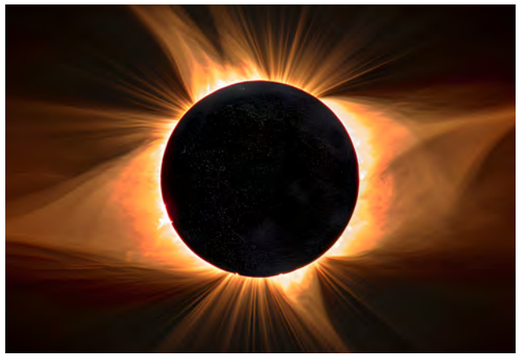
Reference: Gittins, C., 'Robots could build Infrastructure in Space', Electronic Specifier, 2nd. June

Artificial Eclipse captures first Images of Solar Corona

The first successful imaging of the Sun's corona from space has been achieved using a pair of synchronised satellites to create an artificial solar eclipse.

The European Space Agency's Proba-3 mission, which involved 29 companies from 17 countries, used the two satellites Coronagraph and Occulter in high-precision formation flying to recreate the optical alignment of the solar eclipse. The Coronagraph contained the imaging equipment whilst the Occulter, positioned 150 metres away, used a 140cm disc to block the Sun's intense light. A combination of camera technology, laser rangefinding, cold gas propulsion and advanced navigation software enabled the precise alignment required to cast a millimetre-accurate shadow onto the optical system of Coronagraph.

The observation occurred at a distance of around 60,000 kilometres from Earth with each elliptical orbit requiring the two satellites to independently detect, align and maintain their respective positions for up to six hours with a stability of under a millimetre, all without human intervention.



By providing stable and extended eclipse conditions, Proba-3 has enabled researchers to study the Sun's corona in more detail and for longer periods that ever before, helping to potentially mitigate undesirable effects such as solar flares and coronal mass ejections which can interfere with satellites, power grids and radio communications.

Reference: West, P., 'First Images of Solar Corona captured using artificial Eclipse', Electronic Specifier, 17th. June

Bath Space Weather Sensors to launch in 2027

Space weather sensors developed at the University of Bath are due to be launched in 2027 as part of the TOPCAT II project, designed to take measurements of atmospheric conditions in space to inform improvements to technologies such as GPS.

Created at the University of Bath Department of Electronic and Electrical Engineering, the second TOPCAT (Topside ionosphere Computer Assisted Tomography) forms part of the £5.15 million Orpheus mission, which follows from the Prometheus-2 and CIRCE missions which resulted in the loss of the original TOPCAT.

The TOPCAT II payload measures 9x7cm and carries an advanced multi-frequency GPS receiver that aims to estimate the total electron content of the ionosphere, helping to gain a better understanding of the driving processes of geophysical phenomena in the ionosphere-thermosphere system.

Professor Cathryn Mitchell, who helped design TOPCAT, states:

> *"This is an exciting opportunity for us to have our space weather instrument on a satellite and to use the data in the University of Bath MIDAS imaging data assimilation, an advanced algorithm that gives us a highly accurate three-dimensional image of the Earth's ionosphere and its evolution in time".*

Reference: West, P. 'Bath Space Weather Sensors to launch into Orbit in 2027', Electronic Specifier, 20th. June

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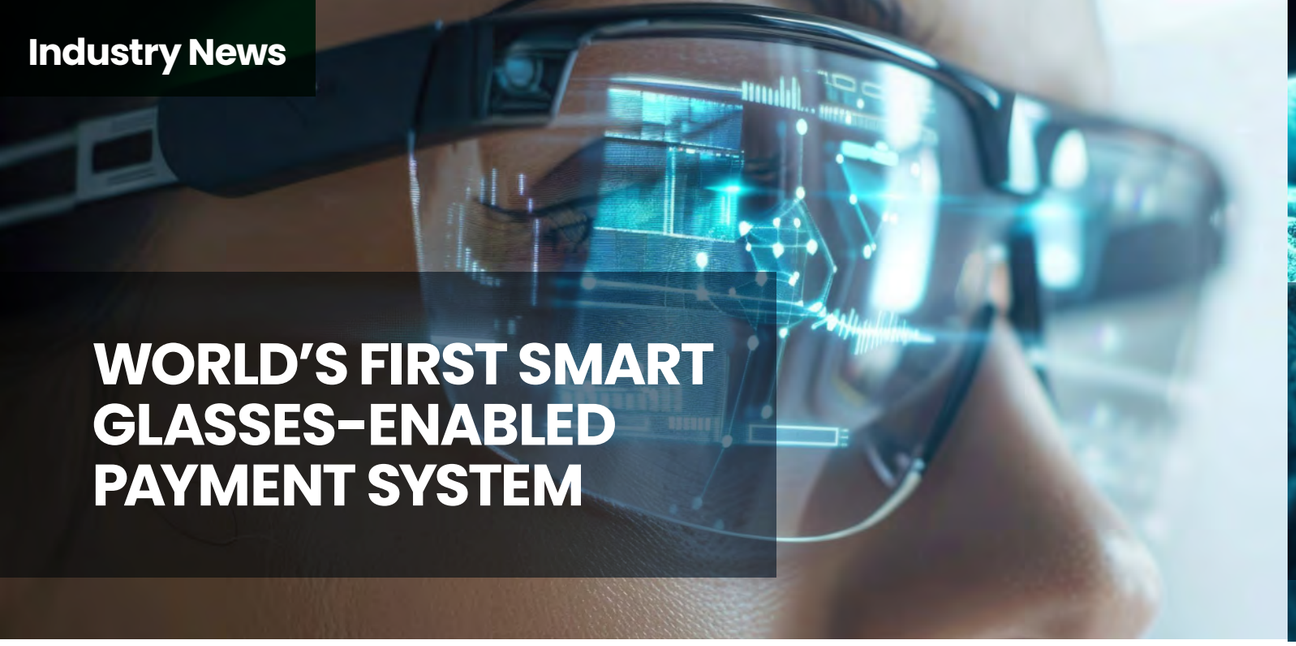


WORLD'S FIRST SMART GLASSES-ENABLED PAYMENT SYSTEM

The world's first real-world smart glasses-embedded e-wallet payment transaction has been implemented in Hong Kong by Alipay+ in collaboration with Meizu.

The successful transaction on Meizu StarV Snap smart glasses on AlipayHK, Hong Kong's leading superapp, represents a milestone in mobile global payment innovation. Users can now make seamless payments with QR scans or voice commands from their smart glasses, backed by the Alipay+ AI-powered voice interface, intent recognition and voiceprint authentication technologies.

Alipay+ advanced payment SDK solutions are now integrated into all new Meizu smart glasses, supported by Meizu's optical waveguide display technology, voice noise reduction and capture technology, and camera-based code scanning technology.

Alipay+ now integrates QR-based and card payments via a global NFC solution. It also enables a full range of agentic AI features including MCP-based AI payments built on Alipay+ GenAI Cockpit, an AI-as-a-service platform.

Peng Guo, General Manager of the XR Division of Meizu, comments:

> *"The offline payment function of smart glasses launched overseas by Meizu and Alipay+ has set a new technological benchmark for the industry. The innovation in the payment scenario has enhanced the practicality and appeal of smart glasses and also promoted the progress and development of the AR glasses industry".*

Reference: 'Alipay+ launches World's first Smart Glasses-embedded Payment Solution', Wear Tech Design, 2nd. July

FIRST CONDUCTIVE YARN STANDARD FOR E-TEXTILE APPLICATION

The Global Electronics Association has announced the publication of IPC-8911 - Requirements for Conductive Yarns for E-Textiles Applications.

This first-of-its-kind global standard establishes a clear framework for the classification, designation and qualification of conductive yarns, addressing some of the long-standing challenges associated with supply chain communication, product testing and material selection within the growing e-textiles industry.

Developed by the IPC Conductive Yarns for E-Textiles Test Methods Task Group, the new standard introduces a standardised designation system and includes qualification and conformance requirements tailored to conductive yarns. It is supported with eight new IPC-TM-650 Test Methods for the evaluation of performance characteristics such as conductivity, mechanical durability and resistance to environmental and chemical exposures.

The release of IPC-8911 is said to mark " a critical step in advancing e-textile integration " by establishing conductive yarns as true electronic building blocks while supporting improved collaboration between yarn suppliers, product developers and original equipment manufacturers (OEMs).

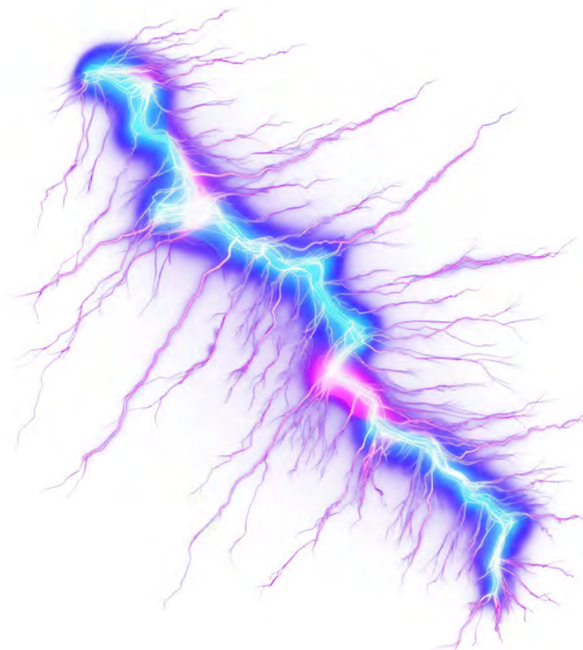
The Task Group included global experts from both the textile and electronics sectors, such as Joe Geiger of Bally Ribbon Mills, who stated the following:

> *"This standard gives manufacturers tools to know what to ask for when ordering yarns and helps yarn suppliers understand the electrical needs their products must meet. It brings clarity to the entire process - acting almost like a recipe for building reliable e-textile systems".*

Another contributor, Sahar Rostami of Meta, expanded:

> *"IPC-8911 eliminates the guesswork. It gives developers, researchers and engineers a common framework and accelerates R and D by reducing the need to reinvent the wheel when selecting and testing conductive yarns".*

Reference: 'The Global Electronics Association releases IPC-8911: First ever Conductive Yarn Standard for E-Textile Application', SMT Today, 8th. July



FULLY-DISSOLVABLE BATTERY RUNS ON PROBIOTICS

Scientists at Birmingham University have designed a battery that works for a short time and then safely dissolves away, leaving no harmful residue behind.

It runs on so-called 'probiotics', the same type of bacteria found in yoghurt supplements, making it a useful invention for such applications as medical implants, environmental sensors and other disposable devices that only require power for a few minutes or hours, collectively known as transient electronics.

Technically these microbial batteries use bacteria to generate electricity by breaking down nutrients and releasing electrons. Ideally the bacteria are of the probiotic type commonly found in food and health products, and a blend of fifteen probiotic strains has been used to produce the said battery.

Once the probiotics are activated, usually by moisture or acidity, they begin digesting nutrients and subsequently release electricity. This effect was demonstrated for the first time by the researchers.

The battery is built on water-soluble paper, which dissolves when wet. A layer of probiotic bacteria is then combined with special electrode materials. A conductive polymer known as polypyrrole, combined with zinc oxide nanoparticles , was used for the anode while Prussian Blue mixed with manganese dioxide was used for the cathode.

The battery is printed or drawn onto the paper using wax or graphite. It can then be adjusted to change the operating time, ranging from four minutes to a hundred minutes, by changing the lengths of the battery's internal paths.

The battery can be prevented from activating too early by coating it in a pH-sensitive membrane, such that it will only begin operating once it has entered a specific acidic environment such as the stomach or polluted water.

The power generated is generally of the order of 4μW, sufficient to power electronics like temporary sensors or wireless signals.

Reference: Miles, S., 'Creating a fully-dissolvable Battery the runs on Probiotics', Electronic Specifier, 21st. July

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FROM THE ARCHIVES

A Fast Recording Spectrograph for Absolute Intensity Measurement of Bright Sources

by E. W. FOSTER*, B.Sc., A.1nst.E.

The spectrum from 3600-6600 Å dispersed by Jarrell-type spectrograph optics is scanned by grating rotation to give a uniform time variation of wavelength at a fixed exit slit. The previously chopped emergent beam passes to a photomultiplier tube, the amplified output being displayed in one dimension with a cathode ray tube and time-resolved with a drum camera. A linear dispersion of 1.8 Å/mm is obtained: the normal scanning rate is 180 Å/sec. Intensity ratios up to about 250/1 can be measured to a few parts per cent. using a single-stage voltage discriminator actuated by the amplified signal, to control the dynode current. At high intensities this current is switched at the 300 cycle chopping rate with the aid of a switching transient neutraliser. A simpler arrangement covering a smaller intensity range is also described. Absolute intensities are measured by comparison at the corresponding wavelength with the radiation transmitted through the same optics from a standard C-arc source. Optics for measuring narrow are channels end-on are outlined.

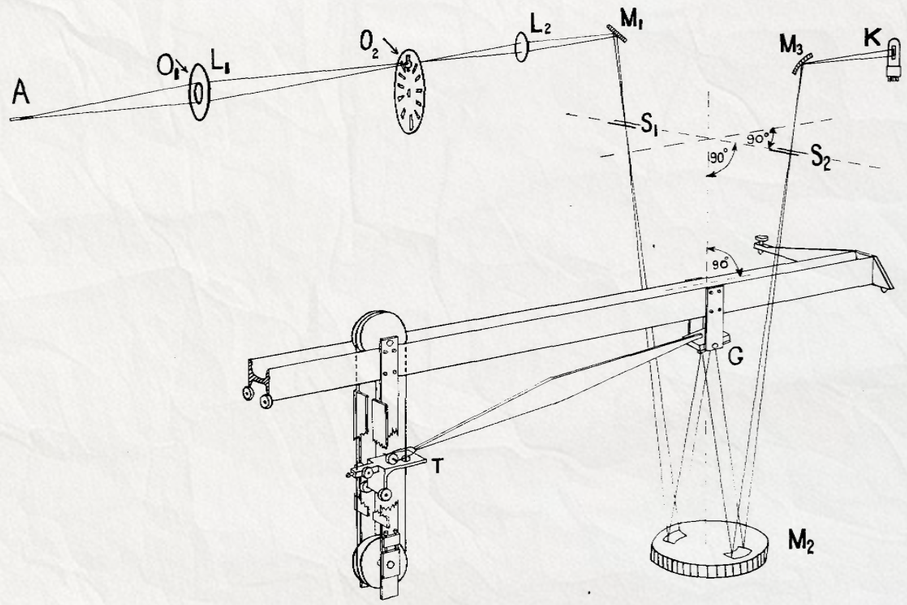

Fig. 1. Diagram of spectrograph, auxiliary optics and (simplified) grating rotation mechanism.

INTRODUCTION

Measurement of the absolute intensity of radiation is important for the investigation of physical conditions in electrical discharges and for the determination of atomic constants of radiation processes.

The apparatus described has been developed to facilitate such intensity measurements. Applications envisaged are particularly to medium power arc discharges (i.e. carrying 50 amps. or so) of a type not easily maintainable in a steady state for much over 15 seconds. These arcs are similar to some of those developed especially at Kiel during the last few years (Lochte-Holtgreven[1]). The fast recording attained, incidentally, provides some degree of time-resolution of the emission, which would be lost by photographic photometry or photoelectric scanning of the spectrum using pen-recorder or other gear of relatively slow response. Although source "noise" which might be thus revealed may be a nuisance, it can, nevertheless; be important to appreciate it as a pointer to otherwise unsuspected discharge processes, neglect of which might invalidate the reduction of the measurements.

*University of London Observatory, Mill Hill Park, London, N.W.7. The experimental work described was done at the Imperial College, London, where the spectrograph is situated.

SPECTROGRAPH AND AUXILIARY OPTICS FROM THE INTENSITY MEASUREMENT ASPECT

The optical arrangement of the spectrograph is that of Ebert as described by Jarrell[2]. This arrangement is well-known and we refer only briefly to it, using the largely self-explanatory fig. 1 which also shows the auxiliary optics. The present spectrograph is vertical.

Firstly, the angular aperture of the beam from the source at A is limited (within the aperture allowed by the subsequent optics) by a stop $0'$ at the condenser lens L_1. This lens images A at a much smaller opening $0_,$, fixed in front of the chopper. Another condenser lens L_1, images 0_2 on to the spectrograph entrance slit S_1, the beam having been turned through 90" by the plane mirror M_1. S_1 is at the focus 10 feet above the 20-foot radius of curvature 12-inch diameter mirror M_1. The parallel beam reflected from M_2 is dispersed by the grating G and refocused at the spectrograph exit slit but in the opposite direction. Emerging from S_2 the beam is again reflected through a right angle, this time by a spherical mirror M_3 and the sagittal image of the short illuminated part of S_2 is formed within the length of the rectangular photocathode at K.

Secondly, the beam section is limited at the three places of focus, the vital places (at present) being S_1 and S_2. The central part of the image of 0_2 formed at S_1 is limited along the length of S_1 by a second slit (razor blades mounted on glass) resting on, perpendicular to, and normally of the same width as the first slit S_1. S_2 finally defines the pulse by selecting its wavelength and range of wavelength.

This light-flux defining arrangement is straightforward for large sources like the 5 mm carbon anode (Euler[3]) of the standard arc (observed perpendicularly to the plane end), but the arcs to be measured in terms of this standard are inconveniently shaped for the purpose, having, at most, dimensions about the length and, so far as the hottest part of the arc is concerned, the width of a rather small pin. Absolute intensities are required in the axial direction from such a source. They are measured by comparing the light flux which would issue from a long thin supposedly uniformly emitting isolated cylinder or prism of the arc plasma with that from an area of the standard carbon anode of the same cross-section, radiating into a narrow cone of the same angle. Comparison of the fluxes then compares the intensities.

Obviously in such a case, the source must be well collimated; also it is necessary to work at small angular aperture here controlled by the stop 0_1. Otherwise since both ends of the source cannot simultaneously be focused on a plane, any hole in the latter (pinhole, slit) centred on the image and of about the image width obstructs light from the front or back of the image cylinder according as the back or the front is focused. The light loss may become enhanced when the 3-dimensional image is reformed at an aperture at each succeeding region of focus in the optical train. To prevent such loss, simple relationships must be satisfied between the angular aperture α of the beam, the slit width d and the width w of the image. In what follows we deal with the problem by geometrical optics. Because of diffraction this is not strictly valid for very small stops (Maecker et al.[4])), which might be necessary.

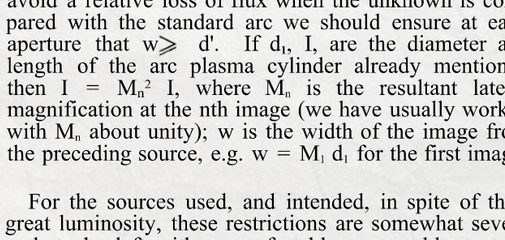

Fig. 2. Limiting rays between two apertures from a luminous region behind one of them.

Consider (fig. 2) a section of the optics affecting the nth image $I_,$, of length I, formed, for example, just to the left of the nth pulse defining aperture S_n, for convenience supposed circular, diameter d. D is the illuminated part of the succeeding lens, distant U from the aperture. We can ask: what minimum width 'must the image have so that the flux transmitted by the hole substantially represents that from a cylinder, diameter d, length I? Consider first the illumination at any point P in D due to the emitting layer of image existing at the front of the image in the aperture. The illumination at P is due to the radiation included in the cone of apex P bounded by the aperture. The same illumination at P will also arise from that area of the layer at the back of the image which is bounded by further extension of the cone. Thus, the whole of the lens, point by point, will be illuminated by the back of the image in the same way as it is from the front, if the diameter d' at the back is given by the projection of fig. 2, so that

$$d' = d + (l/U)(D + d) \doteqdot d + l\alpha \quad \text{.....(1)}$$

where $\alpha = D/U$.

Thus, if w is the actual diameter of the image, then to avoid a relative loss of flux when the unknown is compared with the standard arc we should ensure at each aperture that $w \geqslant d'$. If d_1, I, are the diameter and length of the arc plasma cylinder already mentioned then $I = M_n^2\, I$, where M_n is the resultant lateral magnification at the nth image (we have usually worked with M_n about unity); w is the width of the image from the preceding source, e.g. $w = M_1\, d_1$ for the first image.

For the sources used, and intended, in spite of their great luminosity, these restrictions are somewhat severe and, to be left with a comfortably measurable amount of light it is necessary to work with the spectrograph slit considerably wider than for optimum resolution. The resulting loss of resolving power is not necessarily rele-

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vant to the measurement of absolute intensity*. Even then, to record weak lines it may be necessary somewhat to relax the requirement of equation (1) in one dimension — along the length of S_1 to include radiation from a region demonstrably at a lower temperature than the axial region†. In such a case‡ an empirically determined correction should be applied.

A question of primary importance in using the apparatus is what slit width should be used. The maximum slit width tolerable depends on the lens geometry and the width of the plasma cylinder surrounding the arc axis, across which the intensity can be regarded as uniform. It is therefore necessary to find out what this width is, i.e. to measure the radial intensity distribution in the arc.

The method is to substitute 0_2 by a pinhole — as an optical probe — and move the arc image (in distinct stages) from a position where its centre coincides with the probe centre to a position about 1 mm distant. The grating is set for a bright line. Optics are at the same aperture as before. The distance between the centres of the arc image and probe is measured to about 0.02 mm from photographs taken with a ciné camera (with auxiliary short focus lens). The arrangement is shown in fig. 3 and some photographs in fig. 4. During the period of these operations (¼ minute for the lot) the response is measured electronically using the spectrograph in the normal way described below (except that there is no scanning of the spectrum).

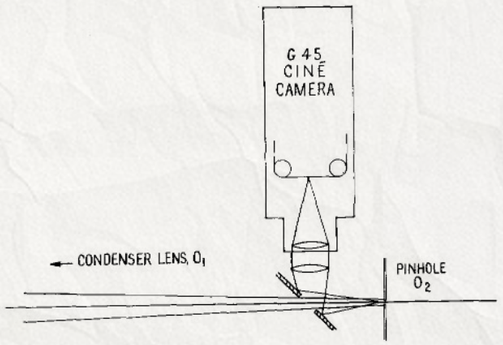


Fig. 3. Machine-gun camera arranged for photographing small displacements between arc image and a pin-hole optical probe.

The distribution thus obtained is still slightly broadened, mainly by the finite width of the optical probe and also the finite aperture of the optics. If necessary, further correction can be applied.

*We have usually worked at about ⅛ the theoretical R.P. of the working aperture; the grating was usually filled only to the extent of a 2 cm disk of light; even half this R.P. would have been sufficient.

†The slice of arc observed measures about 18 X 0.3_5 X 0.3_5 mm³.

‡The present (aluminised speculum) grating is lightly ruled and has no blaze. A factor of 5-10 in light transmission will be gained with a more suitable grating and (1) satisfied rigorously even for recording weak lines. Alternatively there is probably considerable scope for improving the sensitivity from the electronics end.

The cine camera is also useful for providing photographic proof that the arc remains centred on 0, during recording. This can be used to supplement the normal visual check of centring at 0, (by telescopic observation from a position near the arc).

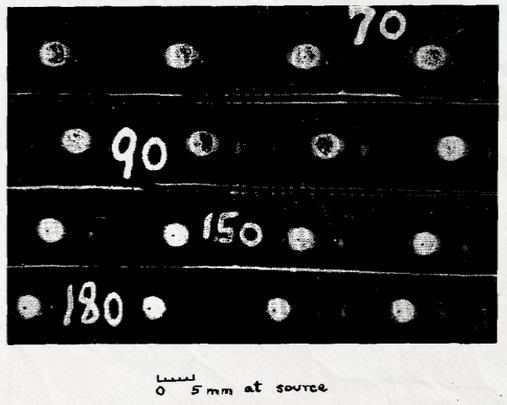


Fig. 4. Sections of film taken with apparatus of fig. 3 (camera speed about 20 frames/sec).

The bright circular patch is the end-on image at the pinhole of a 50 amp. 18 mm long arc in steam. The light transmitted by the pinhole is measured at fixed wavelength whilst the image is moved across it (increasing frame numbers). The arc is very much brighter at the centre than at the edge of the disk but this does not show in the reproduction.

The elliptical patch is a projection of the circular hole in the 45" mirror (fig. 3).

THE CHOPPER

This is a slotted disk driven by the first of four 1/10 h.p. synchronous motors operating various sections of the apparatus. The body of the chopper motor is mounted in a cage and can be rotated through a few degrees about an axis coinciding with the armature axis so that the phase of the pulse is adjustable, in particular with respect to a thyratron quencher driven by one of the other motors.

In all the experiments the chopper produced 300 pulses/sec each of 150 μsec duration. Neither figure is critical; pulsing speed is limited mainly by thyratron deionisation time (and could perhaps be doubled).

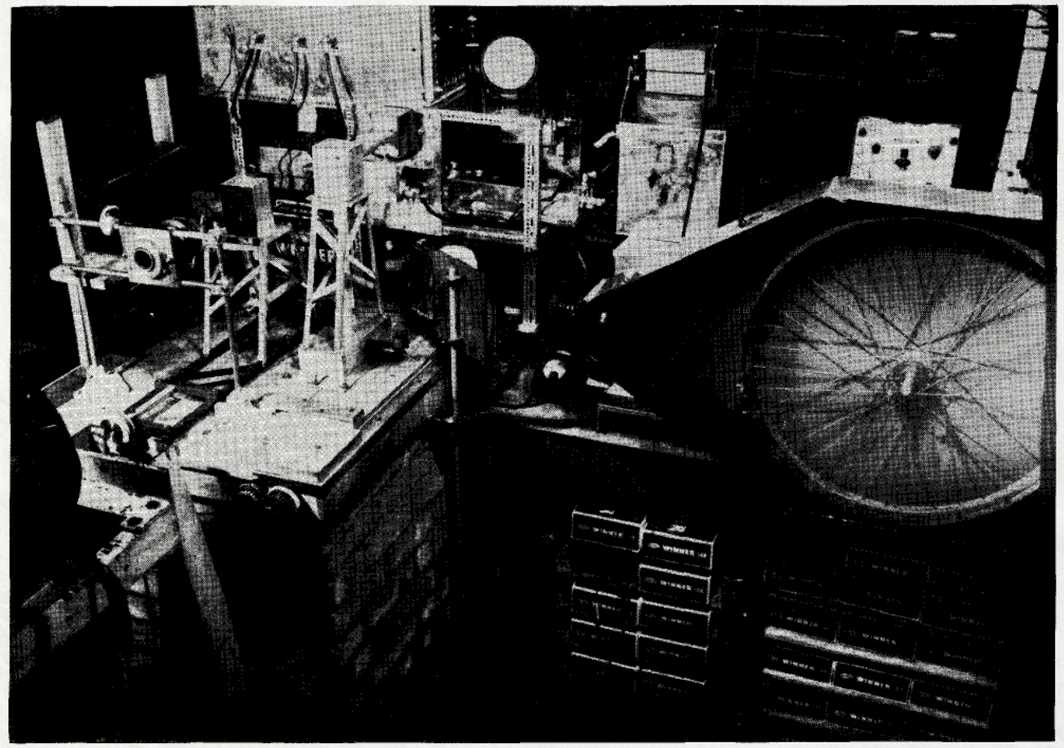
GRATING MOUNTING AND DRIVE

Referring again to fig. 1 the grating G (blank: 13 X 13 cm², ruled: 8 X 5 cm²) is held in a brass box rotatable about an axis parallel to and in the plane of the rulings. Substantial steel pivot studs are supported from a heavy horizontal girder. The pivots are pressed into Vs by strong brass spring strips, the Vs and springs being mounted on the box. The grating rotation is effected by an arm 5 feet long rigidly attached to the grating box at one end and to a ball race at the other. The ball race rests on a smooth, oily, horizontal table T, which itself runs on ball races guided by a vertical track attached to the girder. The table is driven up and down this track, rather like a lift, at constant speed, by a steel cable stretched between pulleys. The upper pulley is rotated through a worm reduction gear from an automatic reversing gear box powered by a second synchronous motor. When the table is at either end of its traverse (over any chosen ⅔ portion of the track length) the reversal is effected electrically by a cam-operated switch. The transmission between the gear box (on a wall bracket) and the worm gear (on the girder) is through stiff rubber hose clamped to the shafts. No detectable vibration is transmitted to the grating. The arm is of light and rigid construction. The grating is used only in the first order.

The principle of this method of grating rotation has, we find, also been used previously (Fastie[5], Badger et al.[6]) in a much more compact form. It evidently produces a uniform time variation of the sine of the angle i between grating normal and vertical. It follows from the grating equation $\lambda = 2a \sin i/\cos \alpha$, that $d\lambda//dt$ is constant, α being the off-axis angle of the incident and diffracted beams, λ the wavelength and a the grating constant 1/590 mm.

The grating mounting is contained in a cellar beneath the laboratory. The girder has the required adjustments and is supported under strain by one adjustable pivot, one ball and two ball races.

The pier supporting the slits, towers for mirrors M_1, M_3 and other equipment, is shown in fig. 5.



Pig. 5. Apparatus assembled near the spectrograph slits.

L.H.S.: Part of chopper is visible (this is mounted on a steel optical bench). Lead-screw for wedge carriage can be seen at end of parallel rails with S_1 between.

Top: Amplifier (360V) battery box with amplifier below and discriminator to right.

In front: Light tubes leading from exit slit S_2 to PMT box, periscope draw tube at bottom of tower. Part of c.r.t. visible above 12in. X 8in. mirror in front of camera lens.

R.H.S.: Drum camera (cover removed).

SPECTROGRAPH SLITS AND PERISCOPE

The entrance slit S_1 is an old bilateral movement by Ottway plus the cross slit already mentioned. The exit slits S_2 of which there are three of different fixed widths, are mounted in cells on a sliding strip. Each can be centred on cross hairs mounted immediately below on a second strip sliding at right angles. Both strips are con-

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tained in a box (fig. 5) on which rests the tower for M_3. The cross hairs, slits, dispersed beam and the mirror M_2 are accessible for examination with a sliding periscope tube. When measurements are intended the tube is retracted and a hole through it clears the light beam for transmission forward to the photomultiplier.

Visual observation of the beam focused on the cross hairs during scanning shows that there is no lateral movement of the beam (exceeding a few hundredths of a mm) except at one end of a run where it amounts to a few tenths of a mm. This seems to be due to a pivot error. It is however of little importance with the present arrangement as the slit S_2 is not restricted over the central part and the image on the PMT is of fairly large area so that a slight lateral movement is unlikely to affect the performance. Periscope examination enables some estimation of primary and secondary chromatism in L_2 and L_1 (respectively quartz 20 cm focus and quartz-fluorite 75 cm focus). These aberrations do not appear to be serious but might present some difficulty if the range of observation was extended to the further ultra-violet. An optical system based entirely on the use of mirrors would be more satisfying if the other aberrations could be brought under control.

ELECTRONIC APPARATUS

The required function is to display the source intensity in one dimension on a c.r.t. screen during high speed scanning with the apparatus already described. Time resolution of this display with a drum camera results in uniform wavelength dispersion. It is desirable to cover at least 3 decades of intensity* so that intensity ratios in the unknown with respect to the standard source can be measured at corresponding wavelengths by comparing spot deflections.

Different approaches to the electronics are described under 1, 2 and 3 below. All methods need a good frequency response otherwise the spot is not fully deflected during the 150 µsec pulse for long enough to photograph satisfactorily on the moving film. Method 3 requires much faster response than methods 1 or 2 to leave time for measurement after a sensitivity change which occurs during the first few microseconds of any strong pulse.

(a) Preliminary Experiments

1. Logarithmic response circuit

Attempts were first made to use a PMT logarithmic response circuit similar to that of Bradford? who employed the principle developed by Sweet[8] and Plymale[9] of working the PMT at constant current using a control valve in the dynode chain. Hariharan and Bhalla[10] using this principle report level response up to 250 cycles/sec. The writer's attempts to get anything approaching a square 150 µsec pulse failed and the scheme was abandoned although the dynode control valve idea is used in (3) below to reduce sensitivity in a linear response system.

*So far we have only got good measurements over about 2.4 decades, which proved adequate for problems on hand.

2. *The HL22 linear d.c. amplifier*

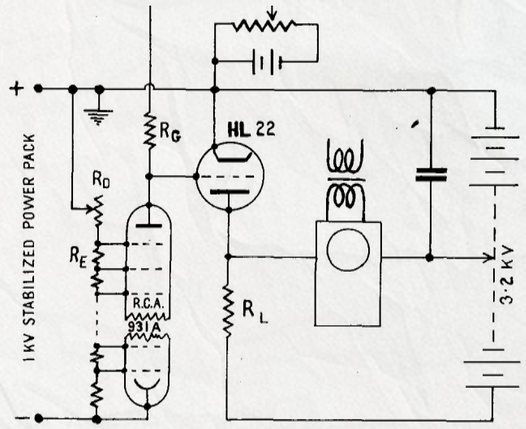

Fig. 6. Simple form of d.c. amplifier arrangement for light measurement.

R_L = 600K R_D = 40K (minimum)
R_G = 100K (minimum) R_E = 100K

The simple circuit of fig. 6 gave a sufficiently square pulse and a nearly linear response over about 1.7 decades of intensity ratio. This is too restricted for general spectroscopic requirements but it might be advantageous in special cases: gain about 80, time constant about 30 µsec (minimum).

The Ferranti HL22 valve, Birtwistle", was found to make an accurately linear d.c. amplifier for oscilloscope driving. Departures from linearity of intensity measurement were mainly due to the drawing of grid current at the operating potential of −1.8V.

For testing purposes the oscilloscope (an old Cossor 3339) was worked with an isolating transformer from the mains but it was found impossible to eliminate 50 cycle pick up entirely, in spite of careful screening, until a battery operated oscilloscope tube was used. A Cossor 09J was available, the potentials being conveniently tapped from the large bank of 120V h.t. batteries supplying the HL22. Stray capacity must be minimised. The PMT was placed in the focal surface of the large Gifford spectrograph[12] at the Imperial College.

The light reaching the photocathode at a given wavelength was controlled by moving an optical wedge* by measured distances across the slit which was illuminated by a tungsten filament lamp operated from a constant voltage transformer. This simple and powerful procedure calibrates the system for intensity ratio measurement independently of wavelength.

The limited speed of the triode precludes its use as an amplifier in the next section.

*An Ilford photographic wedge of known calibration at the given wavelength was used.

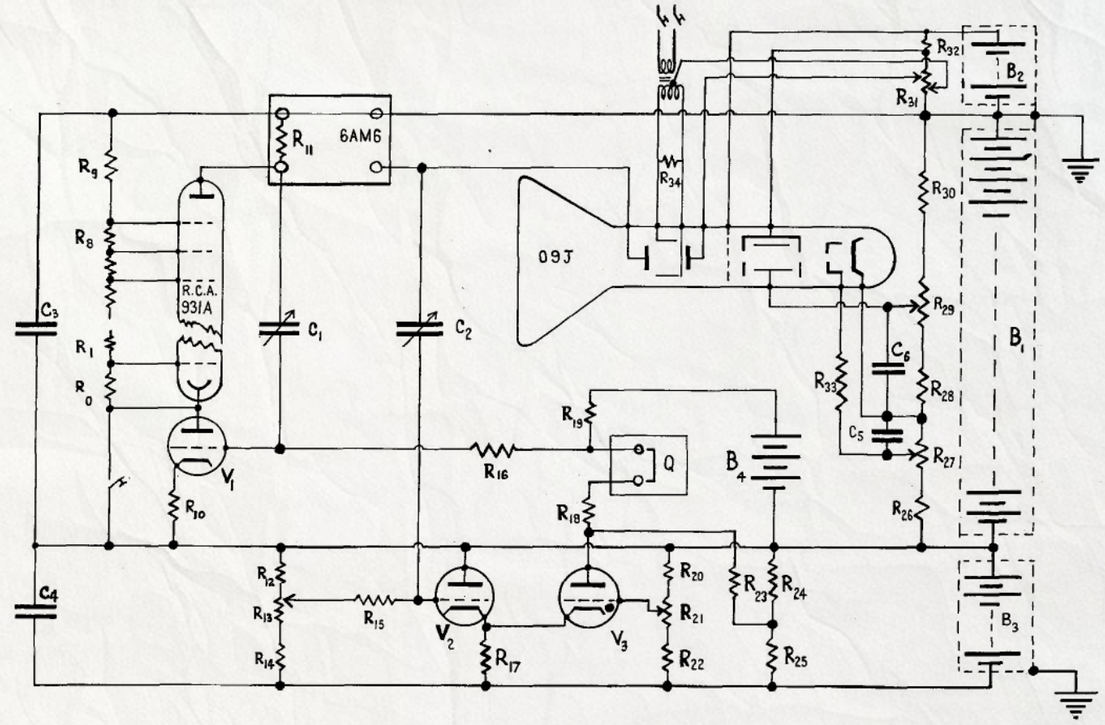

Fig. 7. Pulse amplifier and one-stage voltage discriminator for reducing dynode current.

B_1	885–960 V	C_1	20–100 pF	V_1	12AU7	R_9–R_{10}	10 K	R_{16}	100 K	R_{24}	25 K	R_{30}	335 K
B_2	120 V	C_2	10– 50 pF	V_2	13D3	R_{11}	50–200 K	R_{17}, R_{18}	10 K	R_{25}	100 K	R_{31}	250 K
B_3	240 V	$C_{3,4}$	8 µF	V_3	2D21	R_{12}	170 K	R_{19}	1.4 K	R_{26}	85 K	R_{32}	25 K
B_4	7.5 V	C_5	12 µF			R_{13}	50 K	R_{20}	170 K	R_{27}	35 K	R_{33}	500 K
		C_6	0.2 µF			R_{14}	100 K	R_{21}, R_{22}	100 K	R_{28}	100 K	R_{34}	10 K
						R_{15}	1 M	R_{23}	1 M	R_{29}	250 K		

(b) Equipment in use

(3) The 6AM6 a.c. amplifier and voltage discriminator set

The circuits (amplifier excluded) are shown in fig. 7. The amplified signal is divided, one part deflecting the c.r.t. spot, the other operating a single-stage voltage discriminator controlling the PMT sensitivity. The discriminator acts by reducing the grid voltage of a dynode current control valve when the amplified signal attains sufficient magnitude. In such cases the pulse shows an initial kick of short duration at full sensitivity, which actuates the discriminator, the remainder of the pulse being amplified at the resulting reduced sensitivity. The sensitivity is reset to normal after each 300 c/s pulse.

The arrangement has proved fairly satisfactory and convenient in use in spite of battery operation throughout (including accumulators for heaters). As in the last section, this was adopted mainly to avoid 50-cycle pick up and also because the stabilised power requirements seemed somewhat formidable, likely to take considerable time to develop and (at least from a short-term viewpoint) likely to be the more expensive choice.

THE AMPLIFIER

The amplifier, which we term a 6AM6 for convenient reference, is a 3-valve element of a pulse amplifier essentially as described by Elmore & Sands[13], employing negative feedback and having a loop gain of 100. The valves in our case are 6AM6 type, with 15,000 ohm load resistors and biased to work over negative pulses. The coupling condensers are 0.01 µF capacity. The 6AM6 amplifier is quite fast, the rise time for positive pulses being about half a microsecond. The corresponding figure for negative pulses might be slightly greater. The output is about 200V above earth.

CATHODE RAY TUBE

A Cossor 09J tube is used (with a mumetal screen). This is operated from a battery pack B_1 — which also supplies the dynodes — together with backing off batteries to allow for the 6AM6 output potential and to supply the hood electrode of the 09J. (There is normally no time base for the c.r.t. but a sinusoidal one from a small transformer can be switched in for adjusting transient neutralisation and thyratron firing points: see below).

ONE-STAGE VOLTAGE DISCRIMINATOR

The 6AM6 amplifier is also connected through a small adjustable coupling condenser to the grid of the cathode follower valve V_2 of a fairly fast voltage discriminator arrangement. The cathode follower drives the cathode of a 2D21 thyratron V_3, the grid of which is at fixed potential provided by a voltage divider across a subsidiary battery supply B_3, maintained at about −1kV and supplying the discriminator set. When the negative output pulse from the 6AM6 is large enough the thyratron fires, provided that its anode circuit has been gated by the contact breaker Q. Current then flows from B_3 through the grid bias battery B_4 and its resistor R_{19}, through Q, R_{18}, V_3 and R_{17} (incidentally putting V_2 out of action). The grid potential of V_1 drops suddenly by a fixed amount from the normal potential due to B_4 a few volts above the steady potential of the negative line of B_1. This reduces the current through the dynode resistors and the PMT sensitivity is reduced by a fixed amount until the thyratron is quenched by Q and sensitivity returns to normal.

SWITCHING TRANSIENTS

The sensitivity change, probably as explained below, has an associated switching transient. This is usually sufficient to block the amplifier for considerably more than the 1/300 sec interval between successive pulses unless preventive action is taken.

In the R.C.A. 931A type of PMT the cathode lead lies close and parallel to the anode lead so that appreciable capacity exists between them. When the thyratron fires the control valve grid potential change is very sudden. There follows a rapid change in the potential of the control valve anode and PMT cathode. Capacitative interaction with the PMT anode occurs via the leads and produces the transient. To prevent the amplifier blocking we have attempted to cancel the transient pulse by an equal and opposite transient applied directly from the control valve grid to the PMT anode. This pulse is transmitted through the small capacity C_1. This is adjusted for best cancellation (using the sinusoidal time base already mentioned). The cancellation is inexact because the two pulses are neither simultaneous nor quite of the same shape. They can be brought more nearly in phase by reducing the time constant of the dynode system. We have used 10k instead of the more usual 100 or 200k resistors for the elements of the potential divider and should have gone much lower still had a sufficiently powerful battery or power pack been available (as it is, the dynode current is about 10 mA). Some improvement in cancellation can also be made by the process of slowing down and blunting the grid pulse with the R_{16} resistor, making use of stray capacity to earth (a few μμF). This is an easy but not particularly desirable approach, since, on principle we have attempted throughout to keep the apparatus as fast as possible, consistent with simplicity.

TWO-STAGE VOLTAGE DISCRIMINATOR

The phasing and shaping of the cancelling transient becomes a more serious problem with a 2-stage discriminator built some time ago and partly tested. Preliminary experiments were made from a more satisfying approach using a delay line to retard the cancelling pulse. This appears promising although the line employed in fact produced somewhat too much delay and the expected complications due to unsatisfactory termination. However, if this can be made to work it should be possible to extend the range of reasonably accurate measurement into the 3rd decade of intensity ratio. Other problems arise here again in connection with stabilised power supplies. These developments have been postponed to enable measurements with completed equipment.

THYRATRON QUENCHER

This is a mechanical switch, consisting of copper studs mounted on a brass disk faced with paxolin, nominally flush with the studs. Two high quality (vacuum cleaner) carbon brushes make contact, one, under very considerable pressure, with the studs, the other with the exposed centre of the brass disk.

This switch is driven by a synchronous motor and makes the circuit at the chopping rate. The switch is open for most of the time to quench the thyratron and is only closed for a short period before and after each 300 cycle 150 μsec light pulse. which (as mentioned under "chopper") can be phased with the quencher.

This arrangement makes a quite perfect (if somewhat short-lived) switch once the stud brush is well bedded in. The differential wear of paxolin and brass produces a groove wavy in depth, which greatly improves the performance. It is necessary to have a perfect switch otherwise additional transients are produced which spoil the performance.*

The excessive wear at the switch is not very troublesome since the quencher motor (see below) normally only runs for periods of 17 seconds.

DRUM CAMERA

See fig. 5. This is driven through reduction gearing (like that for the grating movement) by synchronous motor No. 3 which also operates the quencher. The drum is a 26-inch bicycle wheel rimmed to take 70 mm film. It makes one rotation in 17 secs during which time it records about 3000 Å of spectrum. The camera lens is a Kodak Ektar f2.5. The oscilloscope spot is photographed on Ilford 5G91 Recording Film clipped round the drum. The spot is not directly imaged but after reflection (at about 30" incidence) from a 12 inch X 8 inch surface-aluminised plate-glass mirror. This arrangement was employed for convenience of lay-out so that leads to the c.r.t. could be kept to minimum length. The camera has a mechanically operated internal shutter. The drum can be racked on, on its axis, so that several parallel spectra may be recorded on one film (if need be, six within two minutes).

*For the same reason careful insulation throughout the h.t. system is essential to prevent corona (or worse) discharges, especially inside the numerous plugs. Here the insulation had to be improved with paraffin wax.

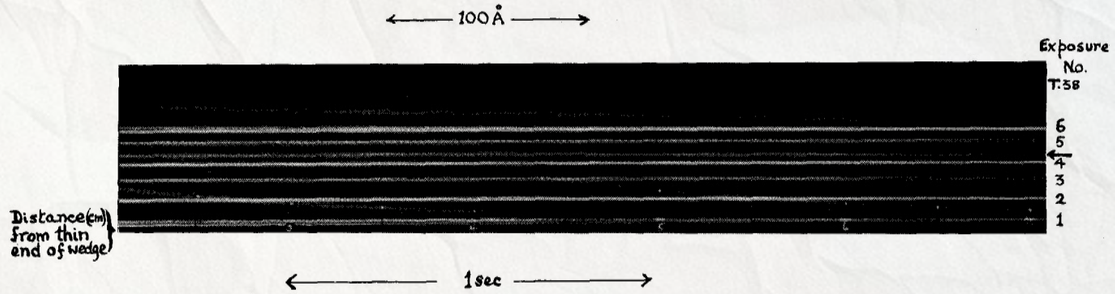

Fig. 8. Contact print of a section of a recording.

No. 1 shows part of a calibration. Sensitivity reduction occurs near the 4.5 cm position.

The zero line. At the r.h.s. this is seen (at about the level of brightness of the spot) through the absorbing strip (text) and also, partly by halation, slightly above the strip. As the amplifier undershooting increases the instantaneous zero moves down and at about the 4.5 cm position exposure above and below the strip is about equal.

The "undershooting" increases further after sensitivity reduction occurs; details of this process are completely lost with this degree of time resolution.

Individual 300 cycle pulses are resolved, particularly in the trace marked with an arrow.

Elongation of the spot is due mainly to astigmatism. The spot is also rather broad.

CALIBRATION

For greatest convenience the c.r.t. spot deflection, as photographed with the drum camera, should be proportional to the intensity for full and reduced sensitivity working.

Performance under working conditions is most readily checked with an optical wedge* more or less as described in (2). Here, the wedge is mounted horizontally in a carriage fitted with three ball races running on a horizontal track perpendicular to the entrance slit S_1. The carriage is driven back and forth with constant velocity by a lead-screw movement, belt operated from an automatic reversing gear box (identical with that for grating rotation) and powered by the 4th synchronous motor of the system. The wedge rests on a fiduciary grid. About three traverses over the slit are obtained per camera drum rotation, The wedge is removed except for calibration.

During the test the grating arm is fixed for some selected wavelength. The slit is illuminated with a steady bright source and the response is recorded during the wedge traverses. Some results are shown for one traverse in fig. 8 and data are plotted† in fig. 9. Sensitivity reduction factors up to 14 have been tested but a value between 3 and 6 has been found more generally useful.

*The "wedge" now in use is made from two equal wedges cemented to form a block 10 cm X 2.5 cm X 0.38 cm. One wedge is clear glass (Chance HC519604), the other so-called neutral glass (Chance ON30, but much less dense than specified). The compound wedge produces no deviation, both wedges having refractive index about 1.52. The density change from one end to the other is 2.52 corresponding to a change in transmitted intensity of 330. The "wedge (one of a pair) was beautifully made by H. Wildey, F.R.A.S., Instrument Maker to the British Astronomical Association.

†This plot is not a calibration, strictly. It is convenient for demonstrating linearity between deflection and transmitted intensity, for getting (a) the sensitivity reduction factor (= antilog of difference of ordinates of the two curves) and (b) the wedge constant, needed for a true calibration curve (which, in fact, we do not use).

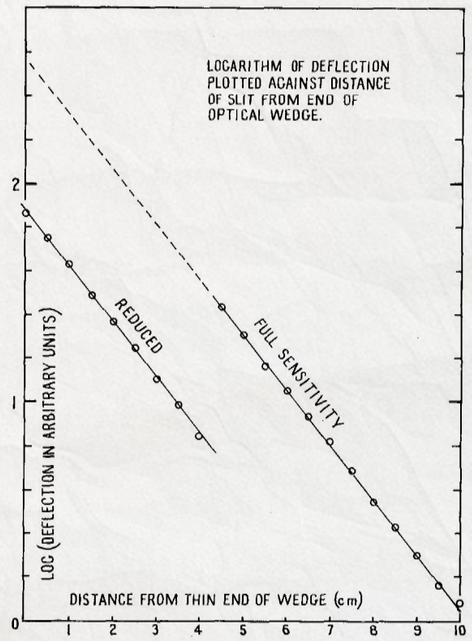

Fig. 9.

It will be seen that departures from linearity are small and for many purposes it would seem perhaps that this calibration is unnecessary. This is not so for the following reasons:—

1. The "calibration" checks the control valve performance. This is operated under rather severe con-

ditions and part of the grid may burn out (with a resulting large decrease in the sensitivity change) unless the valve is cut into the circuit when the apparatus is functioning correctly without it. Smaller sensitivity changes (of about 10%) are liable to occur from time to time. The origin of these has not yet been investigated (it is almost certainly connected with battery performance and might be due to polarisation or temperature change); it is not likely to be of much importance if a set of recordings can be completed within half an hour or so. It is advisable, as usual, to check the constancy of the operating conditions with a standard arc recording, at the beginning and end of a series.

2. The calibration determines whether measurements are being made consistently from a proper origin, in which matter there is some choice. Deflections can be measured either (a) from the normally undeflected (or almost undeflected) zero line traced in the quiescent state between pulses or (b) they can be measured from the estimated deflected zero (when it is resolved). In case (a), it would generally be necessary to use a calibration curve as such. In case (b) the origin for measurement is not so immediately obvious but is easily estimated after a little practice in allowing for the spot size (which limits the intensity resolution). In this case the curves for full and reduced sensitivity arc substantially straight and parallel as in fig. 9. We have much preferred method (b) and have neglected any departure from linearity.

THE ZERO DEFLECTION LINE

The oscilloscope beam is undeflected (at least by the signal) for about 19/20 of the pulse interval and without precaution this would result in severe over-exposure of the zero and loss of intensity resolution on small deflections, etc. During most of this quiescent period the beam should either be extinguished, deflected off the screen, or observed by a stroboscope driven by a 5th synchronous motor. We have employed the simpler but probably less satisfactory method of reducing the actinic effect of the undeflected spot by a factor approaching 20, using a strip of dense green Wratten Filter, just exceeding the spot size, mounted in front of the screen.

As the signal increases the amplifier becomes increasingly undershot and the spot moves from its normal zero position and clears the strip by an increasing amount. With a little experience it is easy to estimate the spot centre in the partially or wholly cleared position. An increasing "undershooting" effect follows when the discriminator has come into action. This can be seen in figs. 8 and 9. Many time-resolved firings have been investigated with a view to introducing modifications to reduce the effect which is related to the transient cancellation. There are good prospects for improvement although at present this seems unnecessary.

MEASUREMENT OF RECORDINGS

A viewing screen is used. Small deflections are measured with a Ramsden eyepiece with graticule. Line profiles are quickly measured with an amanuensis, by laying the film over a sheet of squared paper on the viewing screen and reading off intensity and dispersion co-ordinates in terms of the grid provided; the undershot zero, if there is one, is read off at the same time.

PMT FATIGUE EFFECTS

An error could be caused if PMT fatigue is present, Engstrom[14]. On occasions, near the peaks of very strong lines we have used anode currents about and somewhat exceeding the 10 μA limit recommended by the manufacturers[15] for maximum stability operation. However, during a 17-seconds exposure owing to the chopping, the PMT is only operating for 17/20 sec and is only likely to be used on strong lines for 1/100 to 1/1000 of this period. We have searched for but failed to detect any effects of PMT fatigue.

RECORDING SPEEDS

The speed already quoted of 3000 Å in 17 seconds is well within the capability of the apparatus. If it were necessary only to record broad lines, e.g. Hß shown in fig. 10 (or continua), the speed could be increased by a factor of 10 (or 100) without loss of accuracy except that arising from the presence of 10 (or 100) times fewer signals per unit of wavelength.

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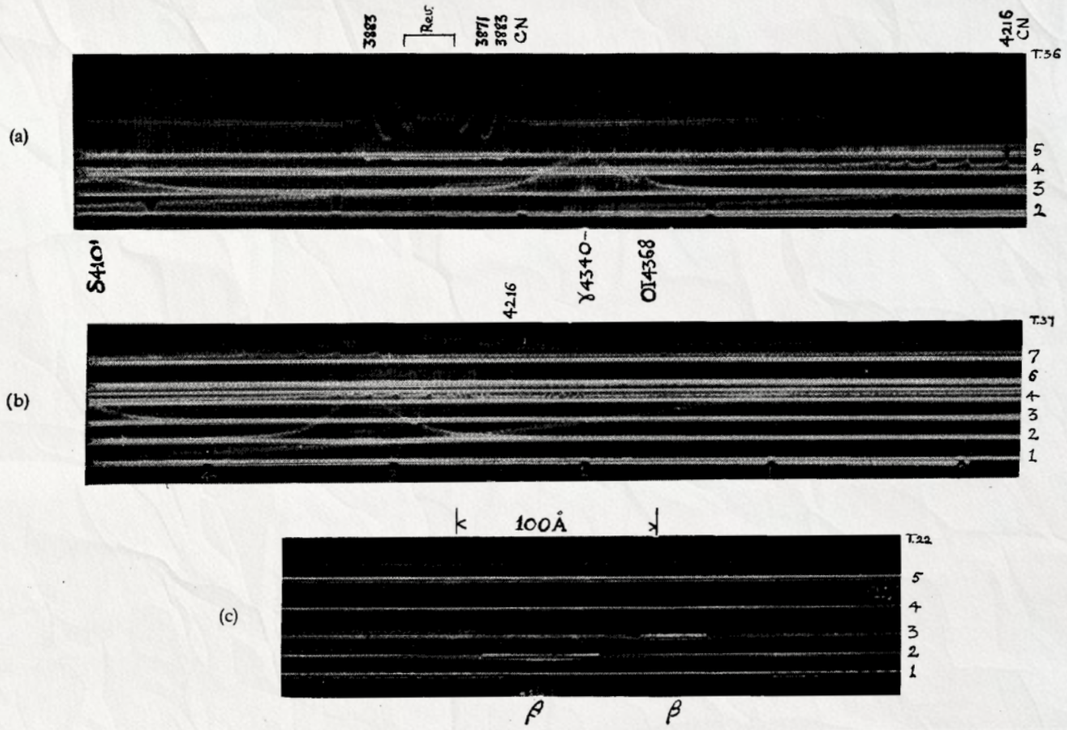

Fig. 10. Contact prints of parts of recordings of spectra under conditions for absolute intensity measurements.

(Note: Individual spectra on a recording are usually displaced mutually in the direction of dispersion).

(a) No. 3: 18 mm long 50 amp. arc in steam end-on showing broad hydrogen lines γ and δ and a sharp 01 line.

No. 4: Standard carbon arc through same optics as No. 3.

No. 5: Standard carbon arc with optics opened up. The grating motion reversed while traversing the CN bands; the 3883Å CN band-head is traced out in reverse. The bands are seen at reduced sensitivity.

(b) No. 1 is,, a calibration and shows fairly considerable "undershooting at the end of the wedge. The deflection here is only about half the maximum measurable on 70 mm film.

No. 6: C arc; optics opened up, firing on heads of 4216Å CN bands.

No. 7: Standard Carbon. Effect of arc hissing (?) shown

(c) No. 2 shows Hß line in 50 amp. arc in steam.

No. 3: same line when a blast of O_2 is injected into arc. Note the great increase in noise due to gas turbulence, although the arc appears steady.

Acknowledgments

The writer wishes to thank Prof. Allen of the University of London Observatory for supporting this work and for several suggestions. Prof. Allen did the final polishing of the 12-inch mirror which is probably true to 1/20 wave over most of its surface.

Prof. Blackett, Prof. Pearse, Dr. Garton and other Authorities at the Imperial College are thanked for their generosity in providing excellent laboratory facilities.

Dr. Folkierski kindly drew out the circuit for the stabilised power pack used in the preliminary experiments and in many earlier photometric calibrations. Dr, Latham suggested smoothing the d.c. arc supply and kindly loaned a 10 mH 100 amp choke for the purpose. Mr. F. Curzon is thanked for bringing the work of Elmore & Sands to the writer's notice.

The spectrograph mounting and gear boxes were made or assembled in the Physics Workshop at the Imperial College under the direction of Mr. T. Shand. The grating arm and thyratron quencher were designed by Mr. A. E. Davies.

The camera, mirror supports, periscope and Folkierski power pack were constructed at the University of London Observatory by Chief Technician C. R. Spratt.

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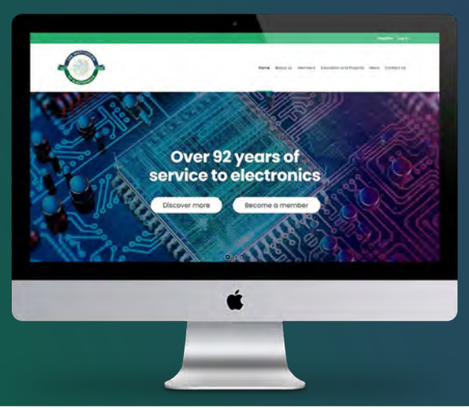

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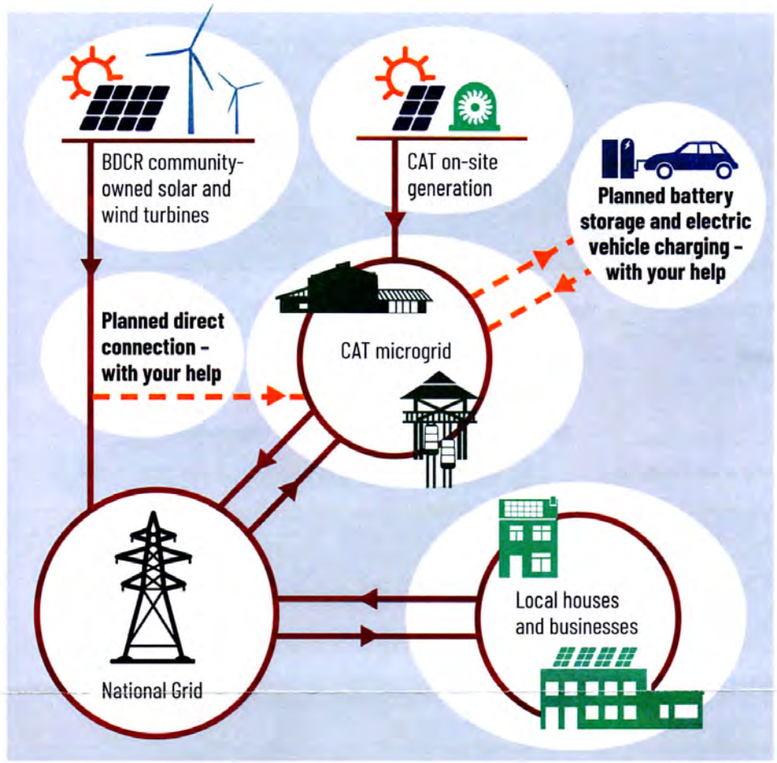
The plan to power CAT using local renewables



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Tim Brewer
BDCR Ltd

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As a company that was born at CAT, we're delighted to be playing a part in securing its future and ensuring it can go on inspiring change."

Andy Skipton Carter
Dulas Ltd

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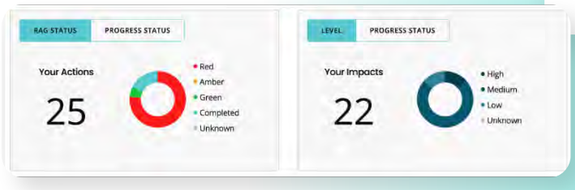

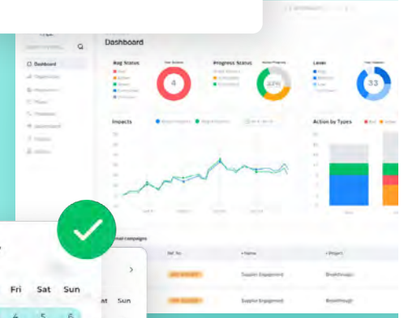

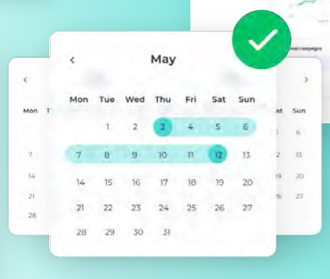

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